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U. S. DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH SERVICE
ANIMAL HUSBANDRY RESEARCH DIVISION
and
COOPERATING WESTERN STATES

W-1 - IMPROVEMENT OF BEEF CATTLE THROUGH THE APPLICATION OF

BREEDING METHODS

1957 Annual Report of W-1

and

Report of

Annual Meeting of Technical Committee

Moscow, Idaho

July 17 - 19, 1957

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ANNUAL MEETING
W-1 Technical Committee
Moscow, Idaho
July 17 - 19, 1957

J. F. Kidwell, Chairman

Members Present:

Arizona
California
Colorado
Hawaii
Idaho
Montana
Nevada
New Mexico
Oregon
U. S. Range Livestock Experiment Station,
Miles City, Montana
Utah
Washington
Wyoming

O. F. Pahnish
P. W. Gregory
H. H. Stonaker
Oliver Wayman
R. E. Christian
A. E. Flower*
J. F. Kidwell
R. L. Blackwell
Ralph Bogart

R. R. Woodward**
J. A. Bennett
S. H. Fowler
P. O. Stratton

Regional Administrative Adviser

S. S. Wheeler

Western Regional Coordinator

R. T. Clark

Agricultural Research Service:

Animal Husbandry Research Division
State Experiment Stations Division

E. J. Warwick
M. J. Burris

* Representing F. S. Willson, Technical Committeeman

** Representing J. R. Quesenberry, Technical Committeeman

The meeting was called to order at 1:30 P.M., by Dr. J. F. Kidwell, who introduced the Dean of the College of Agriculture, University of Idaho, Dr. J. E. Kraus.

Dean Kraus:

I want to take this opportunity to welcome you to the University of Idaho. I thought you might be interested in some facts about the University. In some ways we are unique. The University of Idaho originated by territorial legislation two years before Idaho became a state. Most of our Extension Service staff is located at Boise. We have only four or five of the specialists located at Moscow. We have had a recent change in the way of an addition of a new 250-acre farm about five miles from town. All plant sciences will be moved and the facilities at the University will be used by animal sciences. Again, I want to welcome you to our campus for your W-1 Technical Committee meeting.

Dr. Kidwell:

Thank you, Dr. Kraus, for your welcome.

I hope that we can conduct this meeting in a somewhat relaxed vein. At this time we will introduce the Committee members and guests. (Introductions were made.)

Mr. Charles Bell of the Federal Extension Service is with us but since he cannot stay through the entire meeting he has requested that we start this afternoon by discussing with the group Record of Performance procedures in preparation for next year's meeting, which is to be a joint meeting with the Extension Specialists.

Mr. Bell:

I want to make a few remarks and to open up a discussion around state programs on Record of Performance. This originated last year in Chicago. A research worker from one of the other regions said he had a bone to pick with me. He said, "You Extension people are grabbing the ball on Record of Performance, and we think the research committees should have a hand in it." I said I have been in all states carrying on the work and do not know of a single state where the Extension man has not worked with the research man in the state in developing a program. But we would like to have suggestions from the research committees. From my observations the states themselves are not together. As I look back over this whole program I think it is well it started out as it did. In some other programs the program was completed by a committee which handed down sort of a canned program. I don't think that will work with the beef program. I think with every state developing its own program we have found out a lot we did not know. But I think the time has come now where we need a specific program. Each state says now, "We have a program much better than the other state." I don't think we will or should have a unified program throughout the entire country because the environment is so different over the country no uniform program is desirable. However, we are right now running into a lot of confusion as more bulls having records are bought at the sales and the question arises, "Under what conditions were the records made?" We have evidence of breeders advertising who have not actually tested their bulls.

(Mr. Bell - Continued)

I analyzed copies of state programs and put them on a chart (Table I). You can see the vast differences between state programs. There is even more difference than is apparent on this chart. Sire records and dam records are quite uniform. But when you get beyond that--the method of grading and scoring, adjustment factors--all other factors are up and down the scale. What I would like to do here is to start a little discussion as to where we could begin to pull together maybe one or two of these factors. We should make a little start on it. Age of dam factor--every state within a region could get together. Many state programs are entirely too complicated for the rancher. For research workers it needs to be complicated, but for the rancher it should be flexible. There are states where the Record of Performance program should be considered a Weight for Age Program, but an important program. Ohio requires that carcasses be analyzed.

This Record of Performance is going to be a broad program. One attempt has been made to set up a national program. Membership is still very restricted. But if we do not get together within the Land-Grant College group some breed association or other will set up standards and may embarrass research people. We in Extension would recommend the getting together of research people.

Dr. Kidwell:

Are there any comments?

Dr. Blackwell:

Referring to the New Mexico requirements (Table I), it indicates no sex adjustment. I think you are referring to a particular herd. In that particular instance there is no actual sex adjustment made but there is no need for it because they compare selected animals. We feel ordinarily sex adjustment is necessary.

Dr. Wheeler:

I would certainly like to add to Bell's remarks on Record of Performance just a suggestion or two that might be helpful. I would agree that perhaps the Record of Performance techniques have been quite well explored. There are certain refinements that are probably needed. The thing I had in mind from the standpoint of Bell's plea, we recognize we are working in the Western Region. If this job of trying to pull together Record of Performance standards is worth doing it is going to have to be done in cooperation with NC-1 and S-10 by pulling out of all this mass of information certain broad standards and attempting to get it on a national basis. I think you are all mindful that we do not all agree. If we did, progress would have stopped long ago. If we in the Western Region go along with this suggestion, then I think we are going to have to do it in a planned and organized fashion, putting together information from the other two regions and our Western region. My only contribution is this--perhaps the only approach would

TABLE I

COMPARISON OF STATE PERFORMANCE TESTING REQUIREMENTS

	Grades and Scores	Sire Rec.	Dam Rec.	Weaning Age	Birth Weight	Age of Dam Adj.	Sex Adj.
Arkansas	Fancy 96 - 100 Choice 81 - 95 Good 66 - 80 Med. 51 - 65	Yes	Yes	210	Actual	1st calf + 35 lbs. 2nd calf + 15	B 0 H + 25 lbs.
California	1 92 - 100 2 83 - 91 3 74 - 82 4 67 - 73	Yes	Yes	240	Standard	?	?
Georgia	Fancy 23 - 25 Choice 20 - 22 Good 17 - 19 Med. 14 - 16	Yes	Yes	205	No	Scaled factors for each age range from 1.00 for 6-7 years to 1.16 for 2-12 years	B x .97 H x 1.05
Illinois	Fancy 1 - 3 Choice 4 - 6 Good 7 - 9 Med. 10 - 12	Yes	Yes	215	No	Combined sex and age dam factor 1st calf at 2 yrs. at 3 yrs. 2 yrs. + 130 lbs. 3 75 + 55 lbs. 4 40 + 30 5 10 + 10 9 15 + 15 10 35 + 35	

	Grades and Scores		Sire Rec.	Dam Rec.	Weaning Age	Birth Weight	Age of Dam Adj.		Sex Adj.	
Iowa	Fancy	13 - 15	?	Yes	190	No	2 yrs.	+ 60 lbs.	B 0	H + 35 lbs.
	Choice	10 - 12					3	+ 40		
	Good	7 - 9					4	+ 20		
	Med.	4 - 6					9	+ 10		
							10	+ 25		
Kansas	1	94 - 100	Yes	Yes	210	No	?		?	
	2	85 - 93								
	3	76 - 84								
	4	67 - 75								
Maine	Fancy	15 - 17	Yes	Yes	210	Actual	Combined Factor for Dam and Sex		1st Calf	
	Choice	12 - 14					Mature		Heifer	
	Good	9 - 11					B	.97	1.05	
	Med.	6 - 8					H	1.05	1.13	
							S	1.00	1.08	
Maryland	Fancy	15 - 17	Yes	Yes	210	Standard	Combined Factor for Dam and Sex		1st Calf	
	Choice	12 - 14				60 lbs.	Mature		Heifer	
	Good	9 - 11					B	.97	1.05	
	Med.	6 - 8					H	1.05	1.13	
							S	1.00	1.08	
Mississippi	Fancy	96 - 100	Yes	Yes	205	Actual	Scale of factors ranging from 1.00 to 1.16		B 0	H + 50 lbs.
	Choice	81 - 95							H + 50 lbs.	S + 25
	Good	66 - 80								
	Med.	51 - 65								

	Grades and Scores	Sire Rec.	Dam Rec.	Weaning Age	Birth Weight	Age of Dam Adj.	Sex Adj.
Montana	1 92 - 100	Yes	Yes	No. adj. days.	Standard (To be decided yet)	?	?
	2 83 - 91	Using Card		Index figured from 100 for calf			
	3 74 - 82	Index System		crop average daily gain			
				1 point for each .1 lb.			
				daily gain above or below			
				crop average			
Nebraska	Fancy 13 - 15	Yes	Yes	180	Actual	2 yrs. + 80 lbs.	Sliding scale
	Choice 10 - 12				3	+ 40	
	Good 7 - 9				4	+ 20	
	Med. 4 - 6				9	+ 10	
					10	+ 25	
New Mexico	A, B, C	Yes	Yes	205	No	2 and 11 yrs. + 10%	No sex adj.
	Score weighted by wt./age groups					3 and 10 yrs. + 5%	
New York	Fancy 96 - 100	No	Yes	225	No	2 yrs. + 55 lbs.	Sliding Scale
	Choice 81 - 95					3 + 25	by Age
	Good 66 - 80				4	+ 10	of Calf
	Med. 51 - 65						
North Carolina	Fancy 15 - 17	?	Yes	205	No	?	?
	Choice 12 - 14						
	Good 9 - 11						
	Med. 6 - 8						

	Grades and Scores	Sire Rec.	Dam Rec.	Weaning Age	Birth Weight	Age of Dam Adj.	Sex Adj.
North Dakota	Calf crop group scores						
	Top 1/4 100	?	Yes	190	No	2 yrs. + 60 lbs.	B 0
	2nd 1/4 75					4 + 15	H + 25 lbs.
	3rd 1/4 50					10 + 15	
	Low 1/4 25					12 + 60	
Ohio	Fancy No numerical score	Yes	Yes	Actual average daily gain	Actual	1st calf + 15% 2nd calf + 8%	List sexes on separate sheet for comparison
Oklahoma	Fancy 96 - 100	Yes	Yes	210	Actual	24-28 mos. + 60 lbs.	B - 25 lbs. 1/4
	Choice 81 - 95					29-32 mos. + 50	H + 25 lbs. 1/4
	Good 66 - 80					3 yrs. + 35	
	Med. 51 - 65					4 yrs. + 15	
Oregon	1 92 - 100	?	Yes	Average Daily Gain	Actual	?	?
	2 83 - 91						
	3 74 - 82						
	4 67 - 73						
Pennsylvania	Fancy 90 - 100	Yes	Yes	190	Optional	24-28 mos. + 12%	B - 3%
	Choice 75 - 89					29-32 mos. + 10%	H + 5%
	Good 60 - 74					33-36 mos. + 8%	
	Med. 45 - 59					37-40 mos. + 5%	
						41-48 mos. + 3%	
South Dakota	?	Yes	Yes	190	No	?	?

	Grades and Scores	Sire Rec.	Dam Rec.	Weaning Age	Birth Weight	Age of Dam Adj.		Sex Adj.
Texas	Fancy	Yes	Yes	205	No	2 yrs.	+ 10%	?
	Choice					3	+ 5%	
	Good					10	+ 5%	
	Med.					11	+ 10%	
	Scores based on wt./age groups							
Virginia	Fancy	Yes	Yes	210	Actual	Combined factors for adj. for sex and age of dam		
	Choice					Mature		
	Good					Cow		
	Med.					.97		
						1.05		
Washington	1	Yes	Yes	200	Actual	B		
	2				or	H		
	3				Standard	S		
	4				70 lbs.	2 yrs. + 60 lbs.		
						3 yrs. + 40		
						4 yrs. + 20		
						5-8 yrs. + 0		
						9 yrs. + 10		
						10 yrs. + 20		
						and over		
						S 0		
						B - 15 lbs.		
						H + 25 lbs.		

(Dr. Wheeler - Continued)

be working jointly through committees, if necessary at some set time, and trying to get the three regions together and see if we can get our ideas jelled. This is not going to be an easy task. There are some rather wide differences of opinion, and in many cases they are based on good, scientific background. In trying to get it into industry there will always be variations, statewide and statewise, fully justifiable; but I would like to say that this to me is a worthwhile project and I hope we can work ahead toward bringing the other regions together on it and approaching it on a national basis. That is the only way of getting any uniformity.

Dr. Warwick:

While there are differences in the thinking of research workers, there is also a very great area of agreement. Without exception we are recognizing that records from young cows need adjusting--the area of disagreement is whether it is 10, 12, or 15 percent. Possibly, we are too cognizant of these facts.

Mr. Bell:

Take grade and score--I think all states are looking for the same thing but it is a matter of terminology.

Dr. Warwick:

Some people call a fancy calf a 15, and some a 90.

Mr. Bell:

I realize this is going to be a tough job, but I bring it up because it is something we should be getting to work on. Virginia has been working on it, and two other states are using practically the Virginia standards. Maybe that is the approach.

Dr. Wayman:

Certain factors can be standardized, other points cannot be. Calves raised in California cannot be scored and corrected for the same age of dam as calves in New Mexico on an entirely different plane of nutrition. In Hawaii it varies from ranch to ranch.

Dr. Kidwell:

Bell would not need too uniform a program, but uniform framework.

Mr. Bell:

Get together in principle. It isn't desirable to have it uniform for the nation.

Dr. Bogart:

We could all go along with the idea of this program in general and set down our objectives, and set down production factors which are to be considered. In Oregon a correction factor for the Willamette Valley could not be used in the Squaw Butte-Harney area, but the same objective could be used. If we would put down in a unified form the over-all procedures it would have a lot of merit. We must not confuse "beef cattle improvement" with "rate of gain." Rate of gain is not the only thing we are trying for and measuring.

Dr. Wayman:

Are grades and scores the thing that bother most people? Are those items causing more confusion than correction factors?

Dr. Stonaker:

Next year we will have a joint program with Extension, is that correct? In the meantime, would it be feasible to have a group from the various regions and from the various parts of Extension Service and maybe one or two members from American Beef Cattle Performance Registry Association get together in Chicago and submit a set of recommendations to us by next year and have us discuss it. There are certain things we agree on. We are agreed on weaning weights, fertility, gains, grades, as being important. We use a 200-day weaning weight, but it would not make any particular difference whether it would be 180, 210, or 220. Would it be possible to have something to put to this group next summer? Maybe Warwick's office working with Bell's office could have something.

Dr. Christian:

How about hearing from the Extension people?

Mr. Wade Wells (Idaho):

One of the things we are in need of first out in the field is to have uniform terminology so people understand each other. We have considerable overlapping of states, and it is not easy to have complete understanding. Our old bull grading programs have indicated that. We have never been able to get together in terminology in grading bulls. This has caused a certain amount of difficulty, particularly along state borders. If these things are going to be really valuable in an area where states contribute to each other, similarity would be advantageous. As simple as this could be made, and with the least labor cost, the better this thing will go. Those items will hold us back more than any others.

Mr. Rudy Setzler (Washington):

We have about 150 herds in the state we are supervising on Record of Performance. We have four stumbling blocks--four different methods.

(Mr. Setzler - Continued)

production testing, progeny testing, record of performance testing, rate of gain. If we are going to have a program of wide application we should correct this. The other problem is that we have ranchers with places in both Idaho and Washington. Others in California, Washington, and Idaho. Usually those men are in Record of Performance in each state. One man cannot go through the mental gymnastics of having a herd under California procedures for a few months and in Washington the balance of the period. We are needing every day the adoption of uniform practices. One man will take weaning weight only. The other man adjusts his weights. At first we found fault with that. Then we took a second look and agreed to go along with the individual to the extent he was using a part of the program to improve his herd. When we get a man started weighing his calves we have no trouble selling him improved management practices. We are glad to carry a man as a Record of Performance cooperator if he is starting with weaning weights. When we get scales in we feel that the battle is half won if a man starts keeping accurate records on weaning weights. However, we should have a full program for the man who wants to go on a full program. We cannot force a man to do that, though.

Dr. Stonaker:

I would like to open up the possibility of a group meeting together by the time of the Chicago meeting--a group from W-1 and perhaps an Extension man and representatives from the other two research regions and an Extension man from those regions, with Warwick and Bell--that could set up general principles to throw back to the W-1 Committee, including a name to settle on. This would come back to us at the meeting next summer.

Dr. Fowler:

It would be a mistake to set up uniform practices which would lead to direct comparison between herds under different environmental conditions.

Mr. Bell:

The Extension programs try to discourage competition between breeders.

Dr. Bogart:

I would like to further Stony's suggestion. I think it is very good. It might lead to a solution.

I would like to move that the program Stony outlined be brought into effect.

Mr. Pahnish:

I second the motion.

Dr. Clark:

In discussing this motion and in carrying out the recommendations of the Davis, California, Technical Committee meeting I would like to remind you that we wrote the W-1 committeemen on June 4, 1957, on the subject, "Record of Performance Discussions During the Moscow Meeting," asking that each member consult with the Extension Animal Husbandman in his state prior to our meeting here and list points or questions on Record of Performance procedures which the Extension men would like to have the W-1 committee consider preliminary to a joint discussion next year. The thought was that by our next meeting we could have already worked out the principles presented at this meeting. Actually, we received replies from only a few states.

Dr. Kidwell:

Is there further discussion?

(Dr. Stonaker was asked to restate his proposal as to a committee)

Dr. Stonaker:

One member from each regional beef cattle breeding research project, one Extension man from each region, two men from American Beef Cattle Performance Registry Association, Dr. Warwick, and Mr. Bell. This group will draw up material that will be referred back to the W-1 Technical Committee at the next meeting. This committee would meet either at Chicago or by the time of the Chicago meeting to outline general recommended procedures, to recommend a name for and define Record of Performance work, and make recommendations for nomenclature. These recommendations would then be distributed to Extension and research personnel involved in the Western Region by the time of our next committee meeting in 1958.

Dr. Clark:

Would you consider adding a representative from each of the breed associations? Since these associations are beginning to show interest in this field, I believe it is sound to extend an invitation to them to participate on a committee of this kind.

Dr. Stonaker:

I think they would certainly be welcome participants. The only problem is that it would look like this committee should be composed of people who have been working with this problem of Record of Performance procedures. It might be helpful to have them, though, from the standpoint of working out the practical problems involved.

Dr. Warwick:

I think it might be a very good idea.

Dr. Clark:

Recently, I have picked up information as to how they regard this matter of testing programs, and if we bring in the American Beef Cattle Performance Registry Association and not the breed associations they might feel left out. Even at the risk of having a larger committee, I recommend that they be invited to participate.

(Dr. Stonaker was asked if he wanted to make this addition to the committee.)

Dr. Stonaker:

And a member from the breed associations.

Dr. Kidwell called for a vote on Dr. Bogart's motion that Dr. Stonaker's suggestion be adopted. Motion carried.

Mr. Bell:

That takes care of what I had in mind, and I would like to mention again that Extension has its eyes on what you people in research are recommending. We base our recommendations on recommendations from the research committees.

Dr. Kidwell:

That brings to a close that particular topic.

Dr. Warwick:

Might I suggest that this group designate the member from your W-1 Technical Committee.

Dr. Bogart was named as the W-1 representative to this committee.

UNIVERSITY OF ARIZONA

- I. Station: Arizona Agricultural Experiment Station, Tucson, Arizona
- II. Project Title: Breeding and selection of beef cattle for the Southwest
- III. Personnel:
 - Experiment Station:
 - C. B. Roubicek, O. F. Pahnish, E. B. Stanley, and G. E. Nelms
 - Cooperators:
 - Frank Boice, Jr., Empire Ranch, Sonoita, Arizona
 - Henry Boice, Arivaca Ranch, Arivaca, Arizona
 - Apache Indian Agency and Apache Tribe, San Carlos, Arizona
 - New Mexico Agricultural Experiment Station, State College, New Mexico
 - U. S. Range Livestock Experiment Station, Miles City, Montana
 - U. S. Department of Agriculture:
 - R. T. Clark, Coordinator
 - C. E. Shelby
- IV. Nature and Extent of Work Done This Year:

The accumulation of performance data from the Empire and Arivaca ranches was continued as outlined in the Arizona project. Data accumulated on these ranches over a period of six years have been processed by IBM and are now being analyzed.

Six bulls from the Miles City Station, two bulls raised in the Apache Tribal Herd, and one bull from a privately-owned purebred herd, were bred to 242 registered Hereford cows on the Apache reservation (San Carlos) during the 1956 breeding season. During the 1957 calving season, birth dates and birth weights were recorded. Weights, conformation scores, and condition scores will be obtained on these calves at weaning age, and at six-month intervals thereafter, until an age of two years is attained.

A second bull from the New Mexico Station was bred to dwarf-carrier females and dwarf heifers in the Arizona test herd to produce calves in the spring and summer of 1957. A longheaded dwarf female (Hereford) produced a normal calf sired by this bull. Another bull from the New Mexico Station sired 12 calves in the test herd in 1956. A summary of all matings is reported in Section V.

V. Summary of Progress and Conclusions to Date:

Empire and Arivaca Herds

Regression coefficients for use in adjusting weaning weights to 270 days of age were calculated. The calculations were based on 329 bull calves and 332 heifer calves produced in the two herds over a period of six years.

Preliminary inspection of the plotted data indicated that the weight-age relationship was linear.

Regression coefficients were determined within sexes. Herd and year influences were removed by covariance analyses. The coefficients and confidence limits were as follows:

Regression Coefficients		Confidence Limits (95%)
Bulls	1.442**	1.296 - 1.588
Heifers	1.090**	0.970 - 1.210

Differences among the group regression coefficients within sexes were insignificant at the 5 percent level.

The regression coefficients calculated for the two sexes differed significantly at the 1 percent level.

Regression coefficients for use in adjusting weaning weights for age of dam were attempted by grouping cow ages and regressing the calf weights, corrected to 270 days of age, on the cow-age groups. The three-year-old group weaned the lightest heifer calves; the heifers weaned by four-, eight-, and nine-year-old cows were intermediate in weight; those weaned by five-, six-, and seven-year-old cows were the heaviest and were similar in weight. With the exception of calves weaned by eight-year-old cows, the age of dam grouping was similar for bull calves. The bulls by eight-year-old cows were in the heaviest group.

Regression coefficients were calculated within sexes. Herd and year influences were removed by covariance analyses. The regression coefficients and confidence limits were as follows:

Regression Coefficients		Confidence Limits (95%)
Bulls	24.517**	17.738 - 31.296
Heifers	13.690**	7.337 - 20.043

The differences among the group regression coefficients were insignificant for the heifers, but significant at the one percent level for the bulls. This lack of homogeneity indicates that a single regression coefficient for age of dam corrections is not applicable to the males.

** B significantly different from 0 at 1 percent level

Due to the lack of homogeneity indicated, and the difference in relative weaning weights of bull and heifer calves produced by eight-year-old cows, a further consideration of the data appears advisable.

The regression coefficients, as calculated, suggest the following corrections of weaning weights for age of dam.

Correction to Basis of 5-, 6-, and 7-year-old Cows		
Cow Age	Bull Calves (add)	Heifer Calves (add)
3	50	28
4	25	14
5	0	0
6	0	0
7	0	0
8	0	14
9	25	14

Apache Tribal Herd

A summary of the calving data for 1957 is presented in the following table:

	M.C. Line 1		M.C. Line 6		M.C. Line 9		Private Herd	Tribal Herd	
Bull number	292	398	666	667	677	680	A	489	4108
Cows bred	26	30	33	32	30	30	13	21	27
Calves dropped	21	26	20	19	26	23	11	13	8
Calving %	80.8	86.7	60.6	59.3	86.7	76.7	84.6	61.9	29.6
Calving % with 3-year-old cows omitted	80.8	86.7	85.7	85.7	86.7	76.7	84.6	61.9	29.6
Av. birth wt.	91.1	84.4	80.6	77.1	81.3	86.6	82.2	86.8	88.7
Stillborn			2						1
Abnormal						1			

Overall calving % = 69.01. Percent based on living calves only = 67.77

Bulls 292, 398, 666, 667, ⁶⁷⁷and 680 were purchased from the Miles City Station by the Apache Tribe. Bull A was obtained by the Apache Tribe from a private herd in Oklahoma. Bulls 489 and 4108 were produced in the Tribal Herd.

The low calving percentages of bulls 666 and 667 appear attributable to an excessive allotment of two-year-old heifers during the 1956 breeding season. Only seven cows over two years of age were assigned to each of these bulls, but the limited evidence based on these cows suggests calving percentages comparable to those produced by most of the other bulls.

The low calving percentage of bull 489 could have been due to poor quality semen. The semen from this bull, checked in May 1957, was lacking in sperm concentration and motility.

The low calving percentage of bull 4108 may have been due, at least in part, to an abnormal penis.

The low overall calving percentage seems attributable to bulls 489 and 4108 and to the failure of about 50 percent of the three-year-old cows to produce calves. There is no concrete evidence that bulls 666 and 667 were responsible for the latter failure.

The birth weights reported were adjusted for month of birth and age of dam by correction factors calculated by Rice^{1/} in a study of the Apache Tribal Herd. The weights were further adjusted to a bull calf basis by the addition of 5.4 pounds to the heifer weights. The latter correction was based on the 1957 data.

A multiple range test at the 5 percent level indicated that the calves sired by bull 292 were significantly heavier than those by bull 667. The calves sired by the remaining sires may constitute an intermediate group or may belong in one of the two extreme groups. There were no significant differences between sires within the various Miles City lines.

The estimated heritability of birth weight by intraclass correlation was 45 percent.

One calf that is obviously abnormal was sired by bull 680, but the possibility that the abnormalities observed are of nutritional origin has not been eliminated. Early inability to obtain nourishment from a misshapen udder, followed by severe pneumonia, may have been basically responsible for the lack of growth, emaciation, and enlargement of the knee joints observed. This bull calf weighed 66 pounds at birth.

Bulls 292 and 489 were rejected as sire prospects for the 1957 breeding season because of low sperm concentration and motility. Bull 4108 was eliminated because of poor performance during the 1956 breeding season. Since a few yearling calves sired by bull A apparently had not grown out well, this bull was eliminated at the request of the cooperators. The replacement bulls were produced in the Apache Tribal Herd.

Dwarf Studies, University Test Herd:

A Hereford bull from a line that had produced a lethal condition at birth at the New Mexico Station (Bull 1) sired the 1956 calves in the University of Arizona test herd. The cows in this herd had all produced shorthheaded dwarfs previously. A second bull from the New Mexico Station (Bull 2) having sired lethals in New Mexico, produced the 1957

^{1/} Rice, Frank J. 1956. Factors influencing performance in range Hereford cattle. Ph.D. Thesis, University of Missouri.

calf crop in the Arizona test herd. The calving records are summarized in the following table:

Bull	Heterozygotes	Dwarf Females	Calves Produced		
	Bred		Normal	Lethal	Dwarf
1	16	0	11	1	0
2	15	2	11	0	2?

Bull 1 sired one lethal, as diagnosed by personnel at the New Mexico Station.

Bull 2 sired one stillborn calf that showed no evidence of dwarfism or the lethal condition encountered by the New Mexico Station. The calves produced by the dwarf females were apparently normal, but one of these calves died at three days of age. The cause of death was not established. No evidence of dwarfism or the lethal condition was apparent in this calf.

The percentage of the dwarf calves is considered questionable at present, since the gestation periods of the cows involved could not have exceeded 246 days. These calves weighed 67 and 76 pounds at birth. Blood analyses will be made in an attempt to determine whether these cows could have been exposed accidentally to another bull.

In addition to the matings shown in the table, Bull 2 was mated to a longheaded dwarf female and a normal calf was produced.

VI. Work Planned for the Future:

The work with the Boice herds at Sonoita and Arivaca will continue. The analysis of data collected during the first six years will receive emphasis.

The cooperative program on the Apache reservation will be continued. The original Miles City bulls, with the exception of Bull 292, and four bulls produced in the Tribal Herd, are now being used on cows allotted at random within age groups. Plans for evaluating the relationship between genetic and nutritional influences in this herd are being formulated.

New Mexico Bull 2 will be rebred to the Arizona test herd, including heifers sired by Bull 1, in an endeavor to establish the relationship between dwarfism and the New Mexico lethal. The use of a shortheaded dwarf sire on heifers sired by New Mexico Bulls 1 and 2 is contemplated for the 1958 breeding season.

A small animal laboratory has been added to the research facilities. Laboratory animals will be used for preliminary evaluations of various selection methods and to establish procedure for evaluating heritabilities of metabolic functions.

VII. Publications and Manuscripts:

Roubicek, C. B., R. T. Clark, and P. O. Stratton. 1956. Cattle production: a literature review. I. Reproduction. Ariz. Agr. Expt. Sta. Rpt. 133.

Roubicek, C. B., R. T. Clark, P. O. Stratton, and O. F. Pahnish. 1956. Cattle production: a literature review. II. Prenatal development. Ariz. Agr. Expt. Sta. Rpt. 135.

Roubicek, C. B., R. T. Clark, P. O. Stratton, and O. F. Pahnish. 1956. Cattle production: a literature review. III. Birth to weaning. Ariz. Agr. Expt. Sta. Rpt. 136.

Roubicek, C. B., R. T. Clark, R. M. Richard, and O. F. Pahnish. 1956. Cattle production: a literature review. IV. Postweaning performance. Ariz. Agr. Expt. Sta. Rpt. 138.

Roubicek, C. B., R. T. Clark, O. F. Pahnish. 1956. Cattle production: a literature review. V. Carcass and meat studies. Ariz. Agr. Expt. Sta. Rpt. 143.

Roubicek, C. B., R. T. Clark, and O. F. Pahnish. 1957. Cattle production: a literature review. VI. Maternal factors. Ariz. Agr. Expt. Sta. Rpt. 146.

Roubicek, C. B., R. T. Clark, and O. F. Pahnish. 1957. Cattle production: a literature review. VII. Genetics of cattle. Ariz. Agr. Expt. Sta. Rpt. 149.

Roubicek, C. B., R. T. Clark, and O. F. Pahnish. 1957. Cattle production: a literature review. VIII. Effects of climatic environment. Ariz. Agr. Expt. Sta. Rpt. 154.

Arizona Agricultural Experiment Station. 1957. Research Progress, Calendar Year 1956.

Cattle Inventory
Purebreds

PROJECT SUMMARY
Arizona Agricultural Experiment Station

Breed	Hereford	Hereford	Hereford	Hereford
Herd designation	Empire	Arivaca	Apache	Test Herd
Bulls (12 mos. or over)	4	4	60	-
Cows (12 yrs. or over)	79	81	245	19
Heifers, yearlings	30	28	75	5
Bull calves ^{1/}	25	21	82	6
Heifer calves ^{1/}	30	26	82	7
Percentage used for breeding project ^{2/}				100

Estimated cash value \$32,225 \$31,405 \$108,465 \$3,700

^{1/} Calves born alive. Subsequent losses not deducted.

^{2/} Cooperative projects. No accurate method of determining percentage used for breeding project.

Land, Physical Facilities, and Equipment Used

Item	Number	Actual Cash Value	Percentage Used for Beef Breeding Project ^{1/}
Empire Ranch:			
Land	7 sections	32,330	
Fencing	18 miles	9,000	
Corrals and scales		4,000	
Water supply		3,000	
Total		48,330	
Arivaca Ranch:			
Land	7 sections	32,330	
Fencing	18 miles	9,000	
Corrals and scales		4,000	
Water supply		3,000	
Total		48,330	
Apache Reservation:			
Land	35 sections	103,000	
Fencing	50 miles	20,000	
Corrals and scales		4,000	
Water supply		12,000	
Total		139,000	
Experiment Station:			
Land and facilities		15,000	20

^{1/} Owned by private operators. There is no accurate method of determining percentage used for breeding project.

Cow Production Data^{1/} Arizona Agricultural Experiment Station

Breed	Hereford		Hereford	
Line	Empire		Arivaca	
Cows bred	69		65	
Calves born				
Alive	58		59	
Dead	4		2	
Total	62		61	
Calves weaned	56		55	
% calf crop				
Birth ^{2/}	84.06		90.77	
Weaning	81.16		84.62	

^{1/} 1956 calf crop in Empire, Arivaca, and Test Herds; 1957 calf crop in Apache Herd.

^{2/} Percentage based on calves born alive.

^{3/} Score of 11 is middle-choice feeder grade.

Cow Production Data^{1/}

Arizona Agricultural Experiment Station

Breed	Hereford		Hereford					
Line	Apache		Dwarf Test Herd					
Cows bred	242		17					
Calves born								
Alive	164		10					
Dead	3		2					
Total	167		12					
Calves weaned	-		10					
% calf crop								
Birth ^{2/}	67.77		58.82					
Weaning	-							
	Bulls		Heifers		Bulls		Heifers	
	No.	Ave.	No.	Ave.	No.	Ave.	No.	Ave.
Average:								
Birth weight	82	84.3	82	78.4	-	-	-	-
Weaning age	-	-	-	-	-	-	-	-
Weaning weight	-	-	-	-	-	-	-	-
Adj. weaning wt. - 270 days	-	-	-	-	-	-	-	-
Weaning score								
Cond.	-	-	-	-	-	-	-	-
Conf. ^{3/}	-	-	-	-	-	-	-	-

^{1/} 1956 calf crop in Empire, Arivaca, and Test Herds; 1957 calf crop in Apache Herd.

^{2/} Percentage based on calves born alive.

^{3/} Score of 11 is middle-choice feeder grade.

UNIVERSITY OF CALIFORNIA

- I. Station: California Agricultural Experiment Station, Davis, California
- II. Project Title: Genetic control of hereditary deficiencies in beef cattle with special emphasis on dwarfism

Phases of Work:

1. Genetic analysis of the components of the dwarf complex
2. Cytological and cytochemical analysis of the dwarf complex
3. Progeny testing and the detection of dwarf carriers
4. Anatomical and histological analysis of the components of the dwarf complex
5. Physiological and biochemical analysis of the components of the dwarf complex

Departments and Cooperating Agencies:

Department of Animal Husbandry
School of Veterinary Medicine
U. S. Department of Agriculture, Agricultural Research Service, Denver, Colorado
Other established research groups throughout the country

III. Personnel:

Experiment Station:

P. W. Gregory, L. M. Julian, W. S. Tyler, T. J. Hage, C. E. Cornelius, Robert L. Freeman, D. G. Brennan, Iola Felhaber, and Mary Child

USDA: R. T. Clark, Coordinator, and C. E. Shelby

IV. and V. Nature and Extent of Work Done This Year, and Summary of Progress and Conclusions to Date:

Since the beginning of this investigation over seven years ago, great emphasis has been directed toward genetics and anatomy (including radiography) but considerable attention also has been devoted to physiology, hematology, cytology, and biochemistry (including cytochemistry).

The early exploratory matings suggested a clear-cut hypothesis to account for the genetic relationships of the different dwarf components of the complex. It is only recently that sufficient data have been amassed to prove the correctness of this hypothesis. The anatomical studies are in general agreement with the genetic studies.

The dwarf forms and types of animals subnormal in size which genetic tests indicate are components of the dwarf complex include:

1. Brachycephalic ("snorter") dwarf, in the Hereford and Angus breeds
2. Dolichocephalic (longheaded) type, in the Hereford, Angus, and Shorthorn breeds
3. Comprest, a type subnormal in size but not generally recognized as a dwarf, found in Herefords, reputed by some to have arisen as a dominant mutation, Colorado Domino 68, Reg. No. 181283, being the first mutant

4. Recurrent comprest, identical in phenotype with comprest but not descended from Colorado Domino 68. All animals of this type observed to date have been segregated from Hereford stock of normal size but carrying the recessive dwarf-conditioning gene.
5. Synthetic comprest, phenotypically similar to comprest, can be synthesized at will by crossing brachycephalic and dolichocephalic dwarfs.
6. Compact, an animal of subnormal size, found in Shorthorns, reputed to be conditioned by a dominant gene

The possible relationship of still other phenotypic forms of dwarfs to this complex is being investigated.

Mating tests with proven dwarf-carrier stock of normal size and between different members of the dwarf components justify the following conclusions:

1. Matings among dwarf-carrier Hereford animals of normal size may yield the following classes of progeny: normal size, comprest, dwarfs of brachycephalic and dolichocephalic type, and an intermediate type not heretofore reported.
2. Inter se matings among comprest progeny yield the following classes of progeny: comprest, dwarfs of brachycephalic, dolichocephalic, and intermediate type (same as above), but no progeny of normal size.
3. Matings of all comprest types (comprest, recurrent comprest, and synthetic comprest) to brachycephalic dwarfs yield progeny of the following classes: comprest, dwarfs of brachycephalic, dolichocephalic, and intermediate types, but no animals of normal size.
4. Matings of all comprest types (comprest, recurrent comprest, and synthetic comprest) to dolichocephalic dwarfs yield: comprest, dwarfs of brachycephalic, dolichocephalic, and intermediate type, but no animals of normal size.
5. Matings between a compact type Shorthorn bull and comprest type Hereford cows have produced progeny classified as: comprest, or compact (comprest-compact), dwarfs of brachycephalic, dolichocephalic, and intermediate types, but no animals of normal size.
6. Matings between brachycephalic and dolichocephalic dwarfs within a breed and between breeds yield a reversion type that classifies as comprest (synthetic comprest) and brachycephalic dwarfs. Progeny of dolichocephalic and intermediate dwarf types have not been observed but may be possible.
7. Progeny tests of synthetic comprest produced in 6 above by back crossing to brachycephalic dwarfs yield progeny which classify as: comprest (does not exceed 25 percent of total progeny), brachycephalic dwarfs (not less than 50 percent of the total progeny), dolichocephalic, and intermediate dwarf types. The last two types combined do not exceed 25 percent of the total progeny.
8. Mating tests of synthetic comprest to dolichocephalic dwarfs have yielded a limited number of progeny which classify as: comprest, and dwarfs of brachycephalic and dolichocephalic types.

The results of most of these tests are statistically significant and warrant the conclusion that many phenotypically different forms subnormal in body size are involved in the problem of hereditary dwarfism.

Thus, dwarfism is a complex made up of several components. Results from all the mating tests can be explained by a relatively simple genetic hypothesis if one assumes that each mutant type is homozygous for the same major autosomal recessive dwarf-conditioning gene, and the different dwarf types are differentiated by specific modifying genes or specific combinations of modifiers. The results clearly indicate that the different components of the dwarf complex result from factor interactions.

It is evident from the results that progeny testing to differentiate dwarf-carrier and dwarf-free animals predicated upon the hypothesis that one autosomal recessive gene conditions dwarfism must prove invalid if only the brachycephalic ("snorter") type is classified as dwarf and the remaining dwarf phenotypes are classified as normal. Thus, the problem of progeny testing and the validity of progeny tests have been investigated.

Mating tests of Hereford cows of normal size, previously proven to be carriers of the major dwarf-conditioning gene, mated to proven dwarf-carrier bulls, produced a total of 28 progeny which were classified as: normal, comprest, and intermediate dwarfs, but no brachycephalic dwarfs.

A horned Hereford bull from dwarf-carrier stock is being progeny tested in three ways: (1) by means of heterozygous cows, (2) by means of comprest cows from dwarf-carrier stock, and (3) by means of brachycephalic dwarf cows. Although all the test progeny are not yet born, the results are significant. From the heterozygous cows 19 test progeny have been produced but none were brachycephalic dwarfs, and the bull would be classified as homozygous normal. He did produce dwarfs of intermediate type and some calves of comprest type. From the comprest-type cows he produced calves that classified as: brachycephalic and dolichocephalic dwarfs, and comprest type, as well as some that are not yet classified. On this test, the sire would be classed as a dwarf-carrier. From the mating to brachycephalic dwarf cows he produced to date three progeny, two of which are brachycephalic dwarfs, and a third which is also a dwarf but unclassified as to type.

These tests indicate that progeny testing will prove invalid until all components of the dwarf complex are recognized, and the hypothesis of the inheritance of dwarfism is consistent with the genotypes encountered. Until valid progeny tests can be made, it will be impossible to test the efficiency of any methods for differentiating dwarf-carrier and dwarf-free animals.

Cytochemical studies reveal that the brachycephalic dwarf is deficient in desoxyribose nucleic acid (DNA) but has the normal chromosome number. The blood of the brachycephalic dwarf has normal serum proteins, calcium, magnesium, and phosphorus; serum cholesterol and protein-bound iodine levels are within normal range and indicate that this dwarf is not a primary thyroid cretin. All hematological values appear normal except the differential count.

Anatomy

The anatomical investigations have had several principle objectives:

1. Determination of the process responsible for the dwarfing
2. Determination of the anatomical characteristics of each member of the dwarf complex
3. Determination of breed specific bovine anatomy

The initial objective has been completed successfully, anatomical investigations of the axial and appendicular skeleton of the shorthheaded or IA dwarfs have revealed lesions characteristic of achondroplasia. In the axial skeleton premature fusion of the spheno-occipital synchondrosis was consistently observed. This lesion has been described as pathognomonic of achondroplasia. The observations concerning this lesion are presented in more detail in later paragraphs. The investigation of the appendicular skeleton revealed that the length of the diaphyses is reduced and the length of the epiphyses is normal, a change characteristic of achondroplasia. Detailed results of this investigation are presented in the following paragraphs.

These investigations and the miscellaneous anatomical investigations all contributed toward the achievement of objectives 2 and 3 above.

Investigation of the Appendicular Skeleton

This investigation was undertaken in an attempt to identify the nature of the process responsible for the shorthheaded Hereford dwarf currently classified as type IA. A review of the literature concerning dwarfism in animals and man revealed numerous processes which may result in dwarfed growth. These dwarfing processes may be classified according to etiology as:

1. Endocrine dysfunctions
 2. Nutritional and metabolic disturbances
 3. Specific diseases of cartilage and bone
 4. Miscellaneous types in which the etiology is not understood
- Examples of the latter group are: (a) primordial dwarfism,
(b) progeric dwarfism

Regardless of the etiology, dwarfism is the result of interference with one or more of the normal growth mechanisms. The result is an individual whose body size is reduced either in its linear measurements, weight, or both. The manner in which many of the dwarfing processes act, and the results of these actions on the growth of bone and cartilage, have been extensively studied using gross and microscopic anatomical techniques. These studies have revealed characteristic lesions in the skeletal system for many of the dwarfing processes. Our studies were designed to find the characteristic lesions in the skeleton of the shorthheaded dwarf, and to compare these characteristics with those which result from known dwarfing processes.

Materials and Methods: In this investigation, quantitative anatomical techniques were applied to the bones of the appendicular skeleton. The gross techniques included: (a) visual examination of the stage of fusion of 23 epiphyseal lines, (b) a series of 65 measurements designed to determine the proportionality of the dwarf appendicular skeleton and of its individual bones, and to determine the relative involvement of bone width, total length, diaphyseal length, and epiphyseal length.

These methods are based upon an understanding of the mechanisms by which bones grow. The width of a long bone is increased by the addition of new bone under the periosteum, a process referred to as periosteal growth. The long bones increase in length mainly by endochondral ossification of the epiphyseal and articular cartilages. In the young animal, these cartilages maintain their size by interstitial growth. The dwarfing process may influence one type of bone growth more than the other, or may influence all of them to the same degree. A comparison of the dimension of bones from dwarf and normal Herefords will reveal the influence of the shorthaired dwarf gene on these growth mechanisms.

Microscopic techniques were applied to sections from selected appendicular skeletal lines.

Gross techniques were applied to the appendicular skeletons of 65 Hereford cattle, 32 shorthaired dwarfs, and 32 phenotypically normal individuals. The complete appendicular skeletons of 30 of the dwarfs and 24 of the normal animals were examined. Only metacarpal bones of the other Herefords were available. The phenotypically normal group included animals heterozygous for the dwarf gene and homozygous normal animals. The animals were arranged into four age groups: 0-2 months, 11-13 months, 15-24 months, and 3-17 years. Individuals of both sexes were included, but steers were excluded.

Results: The examination of the appendicular skeletal epiphyseal lines for the stage of fusion indicated that the epiphyseal lines of the dwarf appendicular skeleton tend to fuse at the same age as those of normal Herefords. There were several exceptions: the fusion of a few dwarf epiphyseal lines was premature and a few remained open beyond the normal age of closure. The vast majority of the epiphyseal lines of the appendicular skeleton exhibited similar stages of fusion in dwarfs of similar age and normal Herefords.

The ratios or indices calculated from the bone measurements revealed that the dwarf appendicular skeleton is disproportionate. The disproportionality was evident both in the individual bones and in each limb as a unit. The disproportionalities were more prominent in the young than in the old, and in the metacarpal bone than in the other appendicular skeletal bones.

Twenty-four (24) indices of individual bones were calculated for each of the four age groups. This presented 96 areas for comparison of dwarf and normal indices. The mean dwarf index was numerically

smaller than the mean normal index in 88 of the 96 areas of comparison. There was no overlap of the range of the dwarf and normal indices in 12 of 16 metacarpal indices which were calculated. The four areas in which ranges of metacarpal indices did overlap were in the 3-17 year group. The separation of dwarf and normal indices was greatest in the younger age group. These observations indicate that the dwarfing process is influencing bone growth in the fetus.

The search for an explanation of the disproportionalities was implemented by calculating the percent of normal values for the smallest width, total length, and epiphyseal length. In this calculation, the mean dwarf value was divided by the mean normal value and the resulting quotient multiplied by 100. When these percents of normal values for any one bone are compared, the percent of normal diaphysis length is always the lowest. The total length has the median percent of normal, and the smallest width and epiphyseal length have the highest percent of normal. For example, the percent of normal values for the metacarpal bone from the 0-2 months of age group is:

Diaphysis length	73.4 percent
Total length	78.6
Epiphysis length	104.5
Smallest width	104.2

From this example we can see that the width and epiphyseal length are normal, and that the total bone length is reduced due to a marked reduction of the diaphysis length. The pattern presented here is consistent in all of the long bones of the appendicular skeleton. The diaphysis, or primary center of ossification, is always reduced to a greater degree than the epiphysis, or secondary center of ossification. This pattern is discernible at birth, again indicating an in utero initiation of the dwarfing process.

Data have now been accumulated which indicate that brachycephalic dwarfs, regardless of origin, and whether from cattle of normal size, compressed stock, recurrent compressed, or synthetic compressed, show essentially the same lesion pattern in the premature closure of the sphenoid-occipital synchondrosis and the diaphysis length-width relationship in the metacarpal.

All of the disproportionalities mentioned above are just as evident when animals of similar weight are compared as when animals of similar age are compared.

The gross examination revealed that the results of the dwarfing process were most evident in the metacarpal bone of young Herefords. Therefore, the microscopic examination was concentrated on these epiphyseal lines. Metacarpal epiphyseal lines from six normal and 14 dwarf Herefords under two months of age were examined. In general, the epiphyseal lines of the dwarf appear to be wider than those of the normal Herefords. Varying degrees of disorganization were observed in the dwarf sections. In some dwarfs, the columns of chondrocytes were very poorly oriented, while in others the columns appeared to be as well organized as those of normal animals. The most constant

difference between the dwarf and normal epiphyseal lines was found in the zone of maturing chondrocytes. The maturing chondrocytes of the dwarf appear to be smaller and not as rectangular as those of the normal Herefords.

The lesion in the appendicular skeleton which we have found to be characteristic of the shorthaired Hereford dwarf is a relatively greater reduction in length of the diaphyses or primary centers of ossification than of the epiphyses or secondary centers of ossification. This characteristic lesion was found to be most evident in the young animal, which indicated that the dwarfing process influenced bone growth before birth. Microscopic examination of the epiphyseal lines also revealed characteristic lesions. When these lesions were compared with those of other known dwarfing processes they were found to be identical with those reported in mild hypoplastic achondroplasia. As we found no evidence that would contradict this diagnosis, we concluded that the process responsible for the shorthaired Hereford dwarf is a mild form of hypoplastic achondroplasia.

Field Application: The study of the appendicular skeleton also established criteria by which the type IA dwarf may be segregated from phenotypically normal animals at birth or shortly thereafter. Currently, these criteria are being applied to metacarpal x-rays of approximately 450 Herefords. These x-rays were taken on animals from the University of California dwarf herd and the herds of cooperating purebred Hereford ranchers. In this investigation, an attempt also will be made to correlate the characteristics of the metacarpal bone shortly after the birth of the animal with the weight of the animal at weaning.

VI. Work Planned for the Future:

All research planned for the future is a continuation and expansion of the studies now under way.

Genetics:

1. Continue the studies of the inheritance and genetic relationships of the components now proven to belong to the dwarf complex.
2. Determine the relationship to the dwarf complex of additional mutant types that are subnormal in size.
3. Continue studies to develop more effective means of progeny testing.
4. Produce an F_2 generation from F_1 synthetic compest animals to determine more accurately the number of dwarf modifiers that are involved and the factor interactions.
5. Prepare for publication the results of the several studies that are now completed.

Anatomy:

Proposed Investigations of Cartilage Growth: Anatomical studies which have been completed at the present time have revealed lesions characteristic of achondroplasia. Achondroplasia is a deficiency of interstitial cartilage growth. Very little information is available concerning the manner in which this disease influences cartilage growth.

It appears that a basic investigation of normal cartilage growth and of this disease must be undertaken at this time. Proposed investigations include:

1. The determination of the rate of synthesis of cartilage sulfated mucopolysaccharides by the use of S^{35}
2. The determination of the rate of synthesis of cartilage by the use of Cl^{14} labeled glycine
3. Histochemical investigation of interstitial and perichondrial cartilage from normal and achondroplastic individuals
4. Determination of certain chemical constituents of normal and achondroplastic cartilage

Examples:

- (a) uronic acid
- (b) hexosamine
- (c) monosaccharides obtained by hydrolysis of cartilage chondroitin sulphate

Further Investigations on the Spheno-Occipital Synchondrosis:

As stated above, there are now two quantified changes which have been described in the shortheaded dwarf. In what appear to be normal Herefords, there is range of time of onset and completion of closure of this joint which extends from about the 24th to the 36th month of life. Shortheaded dwarfs show closure times as early as one day. All cases to date have been completed by 5.5 months. This alteration, when present at an early age, definitely classifies the animal as a shortheaded dwarf. Thus, it can be used as a criterion in questionable cases which arise in progeny-testing programs. The alteration can be detected radiologically, but because of the anatomical complexity of the area, much care must be used in taking the pictures and interpreting the results. A report of the results of this phase of the investigation has been submitted for publication.

Variation in the Time of Onset and Rate of Completion of Closure of the Spheno-Occipital Junction: The time of closure and completion of closure, as stated above, are ranges of time within which there is considerable variation. Now that another diagnostic criterion is available (metacarpal dimensions) the factors of closure of the spheno-occipital junction can be more closely defined. These may be related to the degree of expression of the genetic complex which represents the shortheaded dwarf. By a correlation of metacarpal dimensions and status of the spheno-occipital junction it should be possible to determine the frequency of cases in which closure is evident at birth and the rate of closure in this group as compared with other subgroups of the shortheaded type.

An Intermediate Group Showing Early Fusion: Of the phenotypically normal Herefords examined, five have been found which show evidence of closure earlier than normal, but not as early as dwarfs. This group represented ages of 8-17 months. In one instance, complete fusion occurred at 16 months. This group is sufficiently pronounced that it should not be considered as an extension of the "variation of the normal range." It probably represents a distinct group within the pheno-

typically normal population and also a manifestation of the dwarf-conditioning and modifying genes in this population. It is known that at least some of these five animals were of the compressed or compact body type. This phase of the investigation is receiving continued emphasis as it holds promise of assisting in the characterization of intermediate dwarf types. Again, metacarpal dimensions are being correlated with the state of fusion of the speno-occipital junction in these animals.

Breed Differences in Time of Closure: Limited studies to date indicate that there may be a difference in the time of fusion of the various breeds of beef cattle. At least, it appears that closure may be delayed in shorthorned Angus dwarfs when compared with similar animals of the Hereford breed. This question can now be approached since two diagnostic characteristics are available. This study, and the one described above, have a further significance since they might suggest something of the basic factors associated with the time of closure of the joint between the sphenoid and occipital bones.

Factors Responsible for or Correlated with the Time of Closure of the Speno-Occipital Junction: The speno-occipital synchondrosis is distinctive in that its premature closure is related to achondroplasia. Other synchondroses of the body exhibit various responses in this condition. Being related to this cartilage-deficient disease suggests that closure of this joint might be intimately associated with growth processes. Nothing is known of the factors which control or condition the time of closure of this joint. During the past year this question was brought under study. (See previous report). The time of closure in dogs and cattle is being investigated directly in the extensive muscle growth study which will be continued as a part of the dwarf project.

Should it be shown that the time of closure of the speno-occipital synchondrosis is related to physical development and body type, a valuable characteristic might be available for animal improvement programs.

Data have been collected which permit a preliminary evaluation of the growth characteristics of the muscular system of phenotypically normal and dwarf Herefords. The data for one of the 13 muscles have been plotted for phenotypically normal and dwarf animals. These data will be augmented by similar data on the other 12 muscles and should constitute a valuable contribution to the understanding of muscular development in the bovine.

As an aid to the evaluation of the above data, information has been collected on the growth of the gastro-intestinal tract in the bovine. This material will be analyzed during the coming year and will constitute a somewhat complete evaluation of the effect of dwarf-conditioning genes upon the bovine body. These data promise further characterization of intermediate dwarf types.

During the coming year, data on cerebro-spinal fluid pressures and volumes of the lateral ventricles will be evaluated. This material will give further information on variation of effect of dwarf genes within the shorthorned variety.

Muscular Defects: In an attempt to clarify the relation of certain muscular contractures to the dwarf complex, a quantitative anatomical study was started during the past year on animals with twisted necks and twisted limbs. This study involves gross and microscopic aspects of muscles, peripheral nerves, and certain areas of the central nervous system. An accompanying literature survey indicates that the group of conditions seen in cattle may be equivalent to the three major forms of muscular contractures in the human--wry-neck, clubfoot, and elevated scapula. This material promises to be of value in attempting a separation between environmental and genetic forms of these anomalies.

VII. Publications and Manuscripts:

Cornelius, C. E., W. S. Tyler, and P. W. Gregory. 1956. Chemical and hematological studies on blood of bovine dwarfs. Soc. Expt. Biol. & Med. Proc. 92:522-524.

Gregory, P. W. 1956. Phenotypic forms and genetic relationships of the bovine dwarf complex. (Abs.) J. Anim. Sci. 15(4):1207.

Gregory, P. W., and F. D. Carroll. 1956. Evidence for the same dwarf gene in Hereford, Aberdeen-Angus, and certain other breeds of cattle. J. Hered. 47(3):106-111.

Julian, L. M., W. S. Tyler, and P. W. Gregory. 1956. Systematic studies on the anatomical expression of bovine dwarfism. (Abs.) 15(4):1208.

Julian, L. M., W. S. Tyler, T. W. Hage, and P. W. Gregory. 1956. Premature closure of the spheno-occipital synchondrosis in the horned Hereford dwarf of the shorthheaded type. Amer. J. Anat.

Leuchtenberger, Cecilie, Franz Schrader, Sally Hughes-Schrader, and P. W. Gregory. 1956. Certain cytochemical and cytological aspects of dwarfism in cattle. J. Morph. 99(3):481-512.

Tyler, Walter Steele. 1956. The nature of the shorthheaded Hereford dwarf with special reference to the appendicular skeleton. Ph. D. Thesis. University of California.

Tyler, W. S., L. M. Julian, and P. W. Gregory. 1956. Identification of the process responsible for the shorthheaded Hereford dwarf based on anatomical studies. (Abs.) J. Anim. Sci. 15(4):1207-1208.

Gregory, P. W. 1957. Analysis of the bovine dwarf complex. I. The genetic relationship of "compresst" and "compact" types to dwarfism. (In manuscript.)

Tyler, W. S., L. M. Julian, and P. W. Gregory. 1957. The nature of the process responsible for the shorthheaded Hereford dwarf as revealed by gross examination of the appendicular skeleton. (In manuscript.)

VIII. Project Summary:

Critical mating tests under controlled conditions indicate that one autosomal recessive gene conditions bovine dwarfism which can assume several different phenotypic forms. The tests indicate further that specific dwarf phenotypes are differentiated by specific modifying genes or specific combinations of modifying genes. Thus, there is evidence that bovine dwarfism is a "complex" of several components. The brachycephalic ("snorter") dwarf form, of common occurrence, is one of the components most easily identified.

Other components of the dwarf complex are a dolichocephalic (long-headed) type that appears superficially to be proportionate, the "comprest", and the "compact" types. The possibility of other components is being investigated.

The results of all mating tests made to date indicate that there are at least two pairs of modifying genes which modify the expression of the major autosomal dwarf-conditioning gene. Until all the components of the dwarf complex are recognized, progeny testing will prove invalid, since the probabilities based upon a single autosomal recessive gene are in error.

An anatomical study of the brachycephalic dwarf based upon the premature fusion of the spheno-occipital synchondrosis and the length/width ratio of the diaphysis of the long bones (especially pronounced in metacarpals and metatarsals) reveals that the primary deficiency is in the formation of cartilage. This clearly indicates achondroplasia.

Anatomical, physiological, and biochemical techniques are being employed in an attempt to identify the specific lesion, or lesions, that may differentiate the components of the dwarf complex.

California Agricultural Experiment Station
Inventory of the Experimental Dwarf Herd
June 1, 1957

	Number
1. Brachycephalic Dwarfs	
Females, breeding age	35
Males, breeding age	2
2. Dolichocephalic Dwarfs	
Females, breeding age	21
Males, breeding age	1
3. Intermediate Dwarfs	
Females, breeding age	4
4. Comprest Type	
Subnormal in size	
Comprest	
(Descendants of Colorado Domino 68)	
Females, breeding age	7
Recurrent Comprest	
(Not descended from Colorado Domino 68, but	
from normal Hereford dwarf-carrier stock)	
Females, breeding age	10
Males, breeding age	1
Synthetic Comprest	
(From mating different dwarf types)	
Females, breeding age	7
Males, breeding age	3
5. Heterozygous Stock	
Females, breeding age	1

- I. Station: California Agricultural Experiment Station, Davis, California
- II. Project Title: Breeding experiments with beef cattle (Project 1216)
- III. Personnel:
- Experiment Station:
W. C. Rollins, F. D. Carroll, N. R. Ittner, K. A. Wagnon, and J. W. T. Pollock
- U. S. Department of Agriculture:
R. T. Clark, Coordinator, and C. E. Shelby

IV. Nature and Extent of Work Done This Year:

Davis

Testing Bulls Directly and by Use of Progeny for Rate of Gain, Efficiency of Gain, and Earliness of Maturity

This experiment is continuing according to the plan outlined in the W-1 report of three years ago.

Currently, 17 bulls are being individually fed, eight bulls are out in cooperator herds producing progeny test steers, and 39 head of steers are being fed at Davis in the progeny testing of four bulls.

Growth During the Suckling Period

The collection of birth weights, monthly weights to weaning, and body measurements at weaning, is being continued for further analysis of factors affecting growth during this period.

Double Cervix

Cervixes of yearling heifers in both the Davis purebred Hereford herd and the San Joaquin Experiment Range Hereford herd were examined. Of 14 examined at Davis, one heifer had a double cervix. Of 50 examined at San Joaquin Experimental Range, four had double cervixes.

An attempt will be made to preserve the cervix of any cow with this abnormality that goes to slaughter.

Comparison of the California Inbred Line with the Colorado Inbred Lines

Imperial

The crossbreeding experiment continued along the lines previously outlined with the following exceptions.

During the summer, half of the steers were put in the feed lot and the remainder were run on pasture. All of the heifers were run on pasture. This was done in order:

1. To gather more data on a sex x breed interaction during summer growth on pasture.
2. To compare the summer growth rates of the crossbreds with the Herefords under two feeding regimes utilizing different amounts of roughage.

The steers and heifers on pasture during the summer were put on feed around October 1.

The steers on feed during the summer were slaughtered in January. Those put on feed in October were slaughtered in April.

Meat analyses of the above animals were made as outlined in last year's report. In addition to the analyses previously mentioned, the Animal Husbandry Department ran ether extractions on the 12th rib cut.

The meats study was expanded to include consumer surveys conducted by the Home Economics Department on the Davis campus. In these surveys breed and sex comparisons were made utilizing cooked and uncooked loin steaks.

V. Summary of Progress and Conclusions to Date:

Estimates of Degree of Fatness of Bulls and of Steers Using the Antipyrene Method

The results being reported here are of the experiment described in last year's report. The technique outlined by Kraybill (J. Appl. Physiol. 3:681) was followed.

The bulls were tested on three occasions during the feeding trial which ran from February 15, 1956, to June 6, 1956. The steers were tested just once, prior to marketing.

The animals were deprived of water for 12 hours and of feed for 24 hours preceding each trial. An average of the weight at the start and at the finish of a trial was used in the calculations. Each trial took about seven hours.

The results in the following table indicate that the estimates of fat percentage for the bulls were too lacking in precision and accuracy to be of practical use.

Bull No.	Trial 1 3-15-56			Trial 2 4-12-56			Trial 3 6-7-56			Slaughter Grade
	Weight Start	Weight Finish	% Fat	Weight Start	Weight Finish	% Fat	Weight Start	Weight Finish	% Fat	
332	911	880	19.9	-	-	-	1112	1083	27.3	Choice
334	884	856	27.6	-	-	-	1097	1066	8.0	Low Choice
329	986	962	11.8	1046	1030	11.8	1183	1165	0	Top Choice
326	966	940	13.7	1023	1008	8.3	1153	1123	6.2	Choice
348	756	727	10.7	826	814	16.0	970	937	19.2	Choice
335	866	840	21.8	927	913	22.5	-	-	-	Choice
346	837	813	-	906	892	16.2	1047	1022	21.0	Low Choice
336	975	946	-	1058	1042	26.0	1158	1126	8.2	Choice
342	829	808	11.6	919	905	17.3	993	962	11.8	Choice
343	962	932	-	1045	1033	9.6	1148	1117	10.7	Choice

It is felt that these results may in part reflect a lack of control of the fill and a lack of precise knowledge of how the fill may affect the accuracy of the method.

Differences in the degree of excitement of the bulls may have had a bearing on the accuracy of the estimates. This thought was suggested by the fact that the bulls were generally more nervous than were the steers and that the results for the steers were more uniform and reasonable than were those for the bulls.

Percentage Fat			
Steer Number	Antipyrene Method	Specific Gravity Method	Carcass Grade*
92	19.9	19.3	Good
80	23.5	22.9	Choice
04	31.5	24.5	Choice
81	28.8	20.0	Choice
21	27.2	20.4	Choice
96	21.5	20.3	Good
22	23.6	22.1	Good
00	23.9	22.9	Good
95	23.1	23.7	Good
24	20.0	20.9	Good
02	28.4	24.5	Good

* Government grader

Antipyrene injection, blood sampling, and chemical analysis techniques seemed to be under control. A comprehensive report of these trials will appear as a subsection in the Ph.D. dissertation of William N. Garrett concerning the energy requirements of ruminants.

Progeny Test Results

An interesting trend is emerging in the results of the six progeny groups tested to date. In the following table, rate and efficiency of gain in the feed lot for these groups are given, along with the rate of gain of the respective sires from weaning time to feed-lot time, and rate and efficiency of gain in the feed lot.

Bull	Av. Daily Gain Weaning to Feed Lot (88 days)	Av. Daily Gain in Feed Lot	Feed Efficiency TDN/100 Lbs. Gain in Feed Lot	Progeny Av. Daily Gain in Feed Lot	Progeny Feed Efficiency TDN/100 Lbs. Gain in Feed Lot	Comments
188	2.19	2.62	535	2.52	547	
210	1.61	2.48	534	2.44	561	Loaned to same cooperator
183	1.75	3.04	549	2.32	561	
223	1.94	2.76	486	2.49	524	Loaned to same cooperator
194	1.52	2.57	493	2.33	559	
200	1.48	2.76	520	2.04	630	Loaned to same cooperator

There are three criteria by which we can pick the better bull from each cooperator pair. (This is to eliminate ranch bias.) If we use the rate of gain from weaning to feed lot, we pick bulls 188, 223, and 194 as the better bulls. Their progeny had an average daily gain of 2.45 lbs. per day and a feed efficiency of 543 lbs. TDN per 100 lbs. of gain. The poorer bulls are 210, 183, and 200. Their progeny averaged 2.27 lbs. per day and 584 lbs. TDN per 100 lbs. of gain. Let us summarize for each of the criteria for selecting bulls.

Bull Selection Criterion	Ave. Performance in Feed Lot of the Progeny of			
	Better Bulls		Poorer Bulls	
	Daily Gain lbs./day	Feed Effi- ciency Lbs. TDN/100 Lbs. Gain	Daily Gain lbs./Day	Feed Effi- ciency Lbs. TDN/100 Lbs. Gain
Ave. Daily Gain Weaning to Feed Lot	2.45	543	2.27	584
Ave. Daily Gain in Feed Lot	2.29	579	2.42	548
Feed Efficiency in Feed Lot	2.42	548	2.29	579

These results, taken at face value, could imply:

1. That the period right after weaning is a more accurate period to measure rate of gain in bulls than a later period and hence the heritability is higher. This period right after weaning is the period that has been used in the main heritability studies of postweaning gain in beef cattle. This period may be a better period in that differences in rates of maturing do not complicate the interpretation of results so much as in a later period.
2. That a cattleman, by running his bulls in a group for a few months after weaning, and selecting for breeding those with a better rate of gain, could be using the bulls that would produce not only the faster-gaining steer progeny, but also the more efficient in the feed lot. This group testing of bulls in place of individual feeding would be a much simpler and cheaper operation for the cattleman.

When this experiment was designed, one of the hypotheses to be tested was that the testing of bulls at an age closer to that at which their progeny would be evaluated in the feed lot might lead to greater accuracy of selection. The trend in the data so far, as just shown, contradicts this hypothesis.

Heritability of Long-Yearling Weight

The study of long-yearling weight of range heifers described on page 17 of last year's W-1 report has been completed. In addition to the heritability estimates given there (.48 for herd A and -.35 for herd B), the following parameter estimates were made:

	Herd A	Herd B
Genetic correlation of weaning weight with long-yearling weight	.71	+
Correlation of weaning weight with M.P.P.A.*	.16	-.06
Correlation of long-yearling weight with M.P.P.A.*	.36	.01

* Most probable producing ability based on all records available - (Lush, 1945, Animal Breeding Plans, P. 173). A "record" is the weaning weight of a cow's calf.

+ Indeterminate because of a negative estimate of genetic variance of long-yearling weight. A small negative genetic covariance estimate of long-yearling weight with weaning weight along with the above implies a low genetic correlation between these two traits in herd B.

These estimates support the hypothesis that selection for postweaning growth and cow productivity of range cattle is more effective under a nutritional regime that supports continuous growth as contrasted with those range situations in which young growing cattle lose weight during part of the year as a result of deficient nutrition.

Comparative Meat Studies of 3/4 Hereford-1/4 Brahman Calves and Hereford Calves

Food Technology made comparisons between eight Hereford and eight 1/4 Brahman-3/4 Hereford steers to determine if differences were apparent in the eating quality factors between the two breeds. (See page 17 of last year's W-1 report. There it states "seven" instead of "eight" Hereford steers). Rib roasts and sirloin steaks were evaluated by a taste panel to determine the differences in tenderness, juiciness, and flavor. Meat from these same cuts was evaluated for tenderness by a physical method to determine the amount of work (in joules) necessary to grind a measured quantity of meat. Sirloin tip cuts were compared for color differences by both subjective and objective methods. The colormaster was used to determine the differences in darkness.

The results of these tests indicate that differences do exist in the eating quality factors of the Herefords and Brahman-Hereford crosses. Pronounced differences in tenderness were apparent when measured by both objective and subjective methods, the Hereford breed being more tender. The Hereford breed also was rated higher by the taste panel in the juiciness and flavor factors, although these differences were not as striking as the tenderness factor. Color-difference measurements by both panel and colormaster revealed the crossbred to be darker.

VI. Work Planned for the Future:

Work planned for the future has been described in the April 1957 revision of California project 1216 (Breeding Experiments with Beef Cattle). Copies of this revision were recently distributed to W-1 Technical Committeemen.

VII. Publications and Manuscripts:

Rollins, W. C., and N. R. Ittner. 1956. A comparison of the performance of 3/4 Hereford-1/4 Brahman calves with Hereford calves. Western Section, Amer. Soc. Anim. Prod. Proc. 7:LX.

Rollins, W. C., R. C. Laben, and S. W. Mead. 1956. Gestation length in an inbred Jersey herd. J. Dairy Sci. 39:1578-1593.

Cupps, P. T., D. F. Rahlmann, B. McGowan, and W. C. Rollins. 1957. A comparative evaluation of bovine semen following collection with the artificial vagina and the electroejaculator. Western Section, Amer. Soc. Anim. Prod. Proc. VIII-1.

Cattle Inventory
Purebreds

PROJECT SUMMARY
California Agricultural Experiment Station

Breed	Hereford	Hereford
Line	Rover	Brae Arden x Rover
Station	Davis	Davis
Bulls (12 mos. or over)	38	
Cows (2 yrs. or over)	52	
Heifers, yearlings	13	
Bull calves	14	13
Heifer calves	8	13
Percentage used for breeding project	100	100
Estimated cash value	\$47,600.00	\$4,450.00

Grades

Breed	Hereford	Braford	Hereford
Line	-	-	-
Station	Imperial	Imperial	San Joaquin
Bulls (12 mos. or over)	-	-	-
Cows (2 yrs. or over)	13	20	160
Male calves	4	10	140
Heifer calves	9	10	
Percentage used for breeding project	100	100	25
Estimated cash value	\$ 3,700.00	\$5,800.00	\$32,000.00

Young Animals on Feed
Purebreds

	Herefords		Braforads	
	Number individually fed	Number group fed	Number individually fed	Number group fed
Bulls	17			
Heifers				
Steers				
Grades				
Bulls				
Heifers		5		8
Steers		49		10

Land, Physical Facilities, and Equipment Used

[illegible]

[illegible]

Feed Lot Performance California Agricultural Experiment Station

Breed	Hereford	Hereford	Hereford	
Line	Rover	Grade	Grade-Imperial	
Sex	Bulls	Steers	Steers	
Number on test	10	35	5	5
Average: Age on test	389.9	Short Yearling	July 247.0	Oct. 314.6
Initial weight	811.7	678.7	548.4	623.2
Initial score Cond. Conf.	- Low Good	-		
Days on test	112	112	186	193
Gain Total	293.5	257.1	414.0	419.4
Average	2.62	2.30	2.23	2.17
Efficiency of feed utilization #TDN/100# Gain or # Gain/100# TDN	540.0	568.5	Data not avail- able at this time.	
Final weight	1105.2	935.8	962.4	1042.6
Final score Cond. Conf.	Choice	Low Choice to Choice	Jan. L.Ch.	Apr. Ch.

Feed Lot Performance California Agricultural Experiment Station

Breed	Braford		Hereford	Braford	
Line	Grade-Imperial		Grade-Imperial	Grade-Imperial	
Sex	Steers		Heifers	Heifers	
Number on test	5	5	5	8	
Average:	July	Oct.	Oct.	October	
Age on test	242.2	316	326	349	326.2
Initial weight	593.4	629.6	572.4	688.7	594.8
Initial score					
Cond.					
Conf.					
Days on test	186	193	193	102	193
Gain					
Total	408.2	371.0	397.2	250.3	346
Average	2.19	1.92	2.06	2.45	1.79
Efficiency of feed utilization # TDN/100# Gain or # Gain/100# TDN	Data not available at this time.				
Final weight	1001.6	1000.6	969.6	939.0	940.8
Final score	Jan.	Apr.	Apr.	Jan.	Apr.
Cond.	Ch.	Ch.	H. Ch.	L. Ch.	Ch.
Conf.					

COLORADO STATE UNIVERSITY

- I. Station: Colorado Agricultural Experiment Station, Fort Collins, Colorado
- II. Project Title: R & M 26, Improvement of beef cattle through breeding. A study of inbreeding and the crossing of inbred lines within the Hereford breed
- III. Personnel:
- Experiment Station:
- H. H. Stonaker, Kent Riddle, M. H. Hazaleus, T. R. Blackburn, F. C. Daugherty, H. B. Lindholm, Donald Moore, and Walter Rowden
- U. S. Department of Agriculture
- R. T. Clark, Coordinator, and C. E. Shelby

IV. Nature and Extent of Work Done This Year:

Weaning Weights as Influenced by Combining Abilities Among Inbred Lines

O'Brien (M.S. Thesis, 1956), using the techniques developed by C. R. Henderson, estimated the genetic components of variance in crosses among 12 inbred lines and one outbred group. He found 48 percent of the variance in weaning weights to be due to genetic effects associated with maternal ability, 38 percent due to general combining ability, and 6 percent due to specific combining effects. Estimates of effects of line of sire and line of dam were established for 12 inbred lines. The best six lines in general combining ability as measured in weaning weight were: Bonanza, Brae Arden, Colorado, LaPlata, Prospector, and Royal. The best six lines in maternal ability were San Juan, Royal, Outbred, Don, Fort Lewis, and Colorado. General combining and maternal effects were significant, but the two appeared to be uncorrelated. This implies that the calf's inherent growth ability may not be associated with the inherent mothering ability in the line. There was no evidence that sex linkage or specific combining effects contributed significantly to differences in weaning weight among crosses of the inbred lines.

Dwarfism Studies

For the third year, radiographs of lumbar regions of the calves were taken. A pilot comparison of insulin tests and radiographs has been made on a limited number of yearling bulls.

Characteristics of Fast- and Slow-Gaining Bulls

On a within-year basis, unselected yearling bulls were sorted into high-, low-, and intermediate-gaining groups, with approximately equal numbers in each group. As shown in Table I, the faster-gaining bulls were 13 percent heavier at the beginning of the test and their

Table I

All Yearling Bulls on Feed Test at Fort Lewis
1948-1954

	Fastest Gainers	Average Gainers	Slowest Gainers	Fastest Slowest
Number of bulls	113	112	109	
Daily gain	3.08	2.65	2.21	1.39
Initial weight	502.	482.	443.	1.13
Final weight	838.	766.	670.	1.25
Initial age	289.	284.	277.	1.04
Sale price	\$402.00	\$285.00	\$253.00	1.58
Lbs. feed/lb. gain	5.86	6.21	6.43	.91
Age of dam	4.9	5.0	4.1	1.20
Heart girth (cm.)	170.	164.	158.	1.07
Inbreeding of bull	.11	.13	.17	.65
Inbreeding of dam	.07	.08	.09	.78

dams were 20 percent older than the bulls from the least-gaining group. The fastest-gaining group was a third less inbred than its least-gaining group. Thus, initial weight of the bull, age of dam, and its own inbreeding, as well as that of its dam, appear to have a bearing on daily gain in the feed lot. As yet, estimates of the relative importance of those variables and their interrelationships have not been examined.

The Use of W-1 Project Cattle on Related Projects

Because of the increased genetic control made possible by the use of surplus W-1 cattle and because of the interest in genetic studies of variations in palatability and tenderness, cooking tests are being made on heifer carcasses produced on the project. Studies on in vivo fat covering determination by use of the somascope are being continued.

Controls

The second calf crop from the "control" herd of Herefords and the first calf crop from "control" Shorthorn-Angus females are being produced in 1957. The production in this herd will serve as a base of purebreds and crossbreds with which to compare linecross Herefords of a three-line cross.

Linecross Comparisons at Different Stations

First calves are being produced at the California and Colorado stations in a comparison of crossing qualities of Brae Arden and Rover lines at the two locations. In addition, bulls have been sent to the Mississippi station from the California Rover line and from the Colorado Royal and Brae Arden lines. The Coddling Ranch, Foraker, Oklahoma, is crossing with semen from Bonanza and Brae Arden lines as well as the Rover line, and with sires from the Oregon and Miles City stations.

V. Summary of Progress and Conclusions to Date:

The most important findings in 1956-57 are considered to be the appraisal of combining abilities of lines. The most important source of variation in weaning weight is the inherent quality of the line contributing to maternal effect; general combining ability was less important. General combining ability was not closely associated with the ranking of these lines in mothering ability.

VI. Work Planned for the Future:

To continue with present project plans and to complete a bulletin covering the progress of the project to date.

VII. Publications:

Lindholm, H. B., and H. H. Stonaker. 1956. Relative economic importance of traits affecting net income in beef cattle. Western Section, Amer. Soc. Anim. Prod. Proc. 7:LVIII.

O'Bleness, George B. 1956. The combining ability of twelve inbred lines of Hereford cattle. M. S. Thesis. Colorado Agricultural and Mechanical College.

Temple, R. S., H. H. Stonaker, Douglas Howry, Gerald Posakony, and M. H. Hazaleus. 1956. Ultrasonic and conductivity methods for estimating fat thickness in live cattle. Western Section, Amer. Soc. Anim. Prod. Proc. 7:LXX.

DWARFISM STUDIES

A Comparison of Techniques for Identification of NN and Nn Genotypes in Hereford Bulls Born in 1956 at Fort Lewis

	Radiographs		Profiles			White Cell Counts	
	NN B ₁ C	Nn B ₂ B ₃	NN	Nn	Ind.	NN	Nn
Profiles:							
NN	10	8					
Nn	19	11					
Ind.	3	3					
Insulin: White Cell Counts							
NN	10	10	6	13	0		
Nn	3	2	1	3	1		
Differential:							
NN	10	11	7	13		20	0*
Nn	0	1	1	0		0	1

* An insulin retest was recommended for 9 bulls. These results were not included in the comparison of white cell count and differential.

DWARFISM STUDIES

Distribution of Predicted Genotypes of 1956 bulls in various breeding groups at Ft. Lewis Radiograph, R; Profile, P; and Insulin techniques (Iw = white cell, Id = differentials)

[illegible]

Cattle Inventory
Purebreds

PROJECT SUMMARY
Colorado Agricultural Experiment Station

Breed	(Verde)	Hereford				Fort Lewis*	LaPlata†	Mesa*	Rover
Line	Animas	Bonanza	Brae Arden	Colorado	Don				
Station	San Juan Basin Experiment Station, Hesperus, Colorado								
Bulls (12 mos. or over)		1 + 9	7	6	1 + 1	1	1	1	
Cows (2 yrs. or over)	14	12	24	12	20	7	8	3	
Heifers, yearlings	0	1	5	2				-	
Bull calves	0	6	7	6	3	-	-	-	6
Heifer calves	0	5	8	7	5	-	-	-	7
Percentage used for breeding project	100	100	100	100	100	100	100	100	
Estimated cash value									
* On lease.									

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Breed	Monarch	Prospector	Royal	San Juan Red Prince	Tarrington	Control	Crossbred Controls
Line							
Bulls (12 mos. or over)	1 + 2	1 + 6	9	1 + 9	1	1	0
Cows (2 yrs. or over)	17	12	13	17	7	13	9
Heifers, yearlings	1	1	6	6	1	0	0
Bull calves	5	4	2	10	1	2	1
Heifer calves	6	1	1	7	1	3	1
Percentage used for breeding project	100	100	100	100	100	100	100
Estimated cash value							

Young Animals on Feed Colorado Agricultural Experiment Station
Purebreds

	Herefords	
	Number individually fed	Number group fed
Bulls	85	
Heifers	34 (56)	42 (57)
Steers		

Angus Number individually fed	2
--	---

Land, Physical Facilities, and Equipment Used

Item	Number	Actual Cash Value	Percentage used for breeding project
6,000 acres range		\$20,000.00	100
Sheds, corrals, feeders, scales, granaries, etc.		20,000.00	100
Equipment		5,000.00	100

Cow Production Data

Colorado Agricultural Experiment Station

Breed Line-Inbreds and Crossbreds Cows bred Calves born Alive Dead Total Calves weaned % calf crop Birth Weaning	Hereford Bonanza		Hereford Brae Arden		Hereford Colorado	
	Bulls No. Ave.	Steers No. Ave.	Heifers No. Ave.	Bulls No. Ave.	Steers No. Ave.	Heifers No. Ave.
Average:						
Birth weight	11 -		5 -	8 -	7 -	7 -
Weaning age	187		168	185	196	182
Weaning weight:						
Adj. weaning	372		256	294	403	360
Wt. - 200 days**	434		418	457	456	457
Weaning score						
Cond.	-		-	-	-	-
Conf.	-		-	-	-	-

** Includes adjustment for inbreeding.

Colorado Agricultural Experiment Station

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* * Two Don calves gathered late and weaning weights not included in average

Cow Production Data

Colorado Agricultural Experiment Station

Breed	Hereford Royal	Hereford San Juan	Hereford Control
Line-Inbreds and Crossbreds			
Cows bred	18	24	15
Calves born	18	20	15
Alive	0	0	0
Dead	18	20	15**
Total	16*	20	11
Calves weaned			
% calf crop	100.0	83.3	100.0
Birth	88.9	83.3	73.3
Weaning			
			** Included 4 dwarfs.

	Bulls No. Ave.	Steers No. Ave.	Heifers No. Ave.	Bulls No. Ave.	Steers No. Ave.	Heifers No. Ave.
Average:						
Birth weight	8	-	10	6	-	5
Weaning age	209		196	187	201	210
Weaning weight	-	456	-	405	432	-
Adj. weaning wt. - 200 days	505		497	447	424	381
Weaning score						
Cond.	-	-	-	-	-	-
Conf.	-	-	-	-	-	-

* Two Royal calves gathered late so their weaning weights are not included in average.

e. Feed-lot Performance (see General Series Paper No. 663 for details of 1956 feed test).

Colorado Agricultural Experiment Station

Phenotypic Classification of Calves Arranged by Profile Type and by Breeding Tests of Sires and Dams (1953, 1954, 1955, 1956, and 1957)

	Number of Progeny									
	Normal Calves			Dwarf Calves			Premature or Stillborn			Died Before 2 Months
	Sire Classification By Profile			Sire Classification By Profile			Sire Classification By Profile			
	+d	++	Int	+d	++	Int	+d	++	Int	
Proven carrier cows	5			3						
Daughters of proven carrier bulls	11	9					1			1
Daughters of bulls profiled +d	58	36	11				5	3	2	2
Daughters of bulls profiled ++	3	5	9						1	1
Daughters of bulls profiled Int	38	13	11				2		1	
Daughters of bulls, classification unknown	311	67	42	4			17	4	8	2

UNIVERSITY OF HAWAII

- I. Station: Hawaii Agricultural Experiment Station, Honolulu, Territory of Hawaii
- II. Project Title: The improvement of beef cattle through the application of breeding methods (H.A.E.S. Project 268)
- III. Personnel:
 - Experiment Station:
Oliver Wayman, J. H. Koshi, and I. I. Iwanaga
 - Cooperators:
Parker Ranch, Kukaiau Ranch, Kapapala Ranch, and Kaalualu Ranch
 - U. S. Department of Agriculture:
R. T. Clark, Coordinator, and C. E. Shelby
- IV. and V. Nature and Extent of Work Done This Year, and Summary of Progress and Conclusions to Date:

The collection of routine data at weaning, 12 months, and 20 months of age has continued. On the Parker Ranch, weights were determined and recorded on the day each animal reached 240 days, 12 months, and 20 months of age. Grades are assigned to animals as frequently as it is possible to visit the ranch for this purpose. This unit breeds throughout the year. Although most of the calves are dropped during the first four months of the year, the scattering of births throughout the rest of the year makes it difficult to grade all animals at the proper age. Additional weights have been recorded at grading time. These permit a comparison of adjusted weights and actual weights for the same age. Parker Ranch is withdrawing from the program with the completion of data on the 1956 calf crop. These data will be secured in October 1957.

Kukaiau Ranch has suffered so severely from natural causes during the past three years that they have asked permission to withdraw upon completion of data on the 1956 calves. The thin soil on this ranch held little reserve moisture to pull them through the drought of 1953 and 1954. In 1955, the fumes from a volcanic eruption in the Puna District settled on the range in this section of Hawaii and killed the grass back just as it was beginning to emerge from the drought. The effect persisted until late in the summer and was overlapped by the dry season.

On the other two ranches, range conditions have been excellent. These two ranches, Kapapala and Kaalualu, are expanding to 200 and 300 cows, respectively, as rapidly as satisfactory females can be found to augment the herd.

The use of selected sires on randomly allotted cows has resulted in definite weaning weight differences between sire groups. On Kapapala

Ranch, three selected bulls from the John and Mary Crowe herd in California produced calves with the weaning weights shown in Table 1. The calves from Kaalualu Ranch were sired by Mainland-bred bulls brought in for foundation animals.

All of the Kapapala calves were superior to the calves produced previously. Part of the improvement is undoubtedly due to the improvement in dams as these were the upper five percent, phenotypically, of the herd from which they were selected. The Crowe bulls put their stamp on the calves and apparently contributed greatly toward size for age. Sires 7 and 19 were reactors to anaplasmosis. They were culled prior to weaning of their calves.

Table 1. Weaning Weights and Grades on 1956 Calves from Eight Sires and Randomly Assigned Selected Cows (Adjusted to 240 Days)

Ranch	Sire No.	Males			Females		
		No.	240-Day Adj. Weight	Grade	No.	240-Day Adj. Weight	Grade
Kapapala	7	7	693	5.57	8	583	6.25
	19	9	549	4.25	12	496	5.33
	20	12	617	4.82	8	518	5.12
Kaalualu	K948	11	508	4.09	9	472	4.00
	09	17	490	3.59	14	425	3.50
	K939	15	533	4.13	18	469	3.78
	301	12	501	3.83	14	446	4.00
	176	16	469	4.06	11	453	4.55

The data from Kaalualu Ranch lend themselves well toward an estimate of the effect of age of dam on weaning weight of calves. The initial herd was composed of two-year-old heifers and all replacements have been two-year-olds. In addition, the Parker Ranch herd is composed of registered animals of known age at calving. Tables 2 and 3 show the average weaning weights by years and sexes on these two ranches. The results thus far are so variable that it has been inadvisable to use the correction factors for age of dam developed at other stations in computing adjusted weaning weights. Through 1956, the Kaalualu herd represents cows unselected for performance. Because of this the data are more useful than those from Parker Ranch where selection has been exercised and fewer animals are represented in each age group in a given year. The data serve only to show that age of dam correction factors should be used with caution in the population under study.

A preliminary analysis of dam performance indicates that in the herds that have continued uncultured for performance about 2 percent of the cows has produced outstanding calves each year. An additional 15 percent has consistently produced better calves than the herd average by years. Another 15 percent has produced calves below herd average each year.

Table 2. Adjusted 240-Day Weaning Weight of Kaalualu Calves by Years and Age of Dam ^{1/}

Age of Dam at Parturition (Years)		Calving Year				Average
		1953	1954	1955	1956	
Male	3	303 (18)	541 (5)	431 (7)	494 (34)	437 (64)
	4		533 (18)	472 (7)	480 (11)	505 (36)
	5			438 (17)	517 (10)	467 (27)
	6				518 (15)	518 (15)
Female	3	289 (24)	564 (5)	393 (9)	443 (32)	392 (70)
	4		500 (17)	404 (7)	445 (6)	467 (30)
	5			411 (23)	442 (7)	418 (30)
	6				470 (21)	470 (21)

$$\frac{1/}{\left(\frac{\text{Weaning weight} - 70}{\text{Weaning Age (Days)}} \times 240 \right) + 70}$$

Table 3. Weaning Weights of Parker Ranch Calves by Year and Age of Dam ^{1/}

Age of Dam at Parturition (Years)		Calving Year				Average
		1953	1954*	1955**	1956**	
Male	2				535 (1)	535 (1)
	3	524 (2)	466 (13)	504 (3)	560 (1)	478 (17)
	4	556 (4)	465 (6)	499 (9)	580 (1)	491 (16)
	5	492 (4)	533 (5)	485 (1)	585 (7)	557 (13)
	6		586 (3)	502 (6)	610 (1)	542 (9)
	7	544 (2)		553 (3)	550 (2)	552 (5)
	8		481 (1)			481 (1)
	9		440 (1)			440 (1)
	10	537 (5)	524 (2)	497 (2)		511 (4)
	11	556 (4)	553 (4)	525 (2)	565 (1)	547 (7)
	12	418 (1)	571 (2)	507 (2)	590 (1)	539 (4)
	13	487 (1)	578 (2)	435 (1)		545 (4)
	14		415 (2)	610 (1)		479 (3)
	16			570 (1)		570 (1)
	17	510 (1)				510 (1)
Female	2				448 (3)	448 (3)
	3	376 (3)	427 (11)	419 (4)	460 (1)	427 (16)
	4	436 (8)		407 (9)	455 (5)	424 (14)
	5	398 (4)	446 (9)	407 (3)	475 (6)	449 (18)
	6		388 (4)	459 (4)	497 (2)	438 (10)
	7			414 (4)	517 (5)	471 (9)
	8	527 (2)	470 (2)		515 (2)	492 (4)
	9		417 (2)	332 (2)		375 (4)
	10	411 (6)	335 (1)		475 (1)	405 (2)
	11	442 (2)	421 (2)	415 (1)		419 (3)
	12	344 (1)	448 (2)	410 (1)		435 (3)
	13		471 (1)	390 (3)	580 (1)	444 (5)
	14	499 (1)				499 (1)
	18			400 (1)		400 (1)

^{1/} Number of calves in parenthesis

* Calculated 240-day weights from 210-day weights

** Actual 240-day weights

VI. Work Planned for the Future:

Project work will continue as outlined.

An analysis of dam performance will be made to develop criteria for early culling of inferior cows.

Project will be revised. This has been delayed to permit full participation in the revision by a new geneticist and biometrician being hired in the department.

VII. Publications and Manuscripts:

None.

Cattle Inventory PROJECT SUMMARY Purebreds Hawaii Agricultural Experiment Station

Breed	Hereford		
Line	A		
Station	Parker		
Bulls (12 mos. or over)	17		
Cows (2 yrs. or over)	130		
Heifers, yearlings	28		
Bull calves			
Heifer calves			
Percentage used for breeding project	25		
Estimated cash value	\$91,500.00		
Grades			
Breed	Hereford	Hereford	Hereford
Line	C	D	E
Station	Kukaiau	Kaalualu	Kapapala
Bulls (12 mos. or over)	33	73	3
Cows (2 yrs. or over)	86	252	90
Male calves		93	38
Heifer calves		87	27
Percentage used for breeding project	49	100	100
Estimated cash value	\$35,150.00	\$112,750.00	\$42,400.00

Young Animals on Feed - None.

Hawaii Agricultural Experiment Station
Land, Physical Facilities and Equipment Used

Item	Number	Actual Cash Value	Percentage Used for Breeding Project
A. Land	525 acres	\$52,500.00	25
Corrals, chutes, scale	1 set	3,500.00	25
C. Land			
Corrals, chutes, scale	1 set	3,000.00	80
D. Land	1,150 acres	12,600.00*	
Corrals and chutes	1 set	2,400.00	100
Portable scale	1	650.00	80
E. Land	924 acres	10,123.00*	100
Corrals, chutes, scale	1 set	3,300.00	100
University of Hawaii			
Portable scale	1	720.00	80
Profilometer	1 set	200.00	100
Leica camera set	1	590.74	50
Total		\$89,583.74	
* Annual lease value			

Cow Production Data

Hawaii Agricultural Experiment Station

Breed	Hereford		Hereford	
Line				
Cows bred	100		90	
Calves born				
Alive	59		86	
Dead	0		0	
Total	59		86	
Calves weaned	55		68**	
% calf crop				
Birth	59		95.5	
Weaning	55		75.5	
</				

* 9 = Top
 1 = Bottom

** Difference due to castrates eliminated

Cow Production Data Hawaii Agricultural Experiment Station

Breed	Hereford				Hereford			
Line								
Cows bred	179							
Calves born								
Alive	142							
Dead	0							
Total	142							
Calves weaned	137							
% calf crop								
Birth	79.3							
Weaning	76.5							
	Bulls		Heifers		Bulls		Heifers	
	No.	Ave.	No.	Ave.	No.	Ave.	No.	Ave.
Average:								
Birth weight								
Weaning age	236		228		196		207	
Weaning weight	71	490	66	431	28	517	28	466
Adj. weaning								
wt. - 240 days	499		452		614		528	
Weaning score								
Cond.								
Conf.	71	3.0	66	3.6	28	4.5	28	5.5

Feed Lot Performance - None

Phenotypic Classification of Calves Arranged by Profile Type and by Breeding Tests of Sires and Dams - None

UNIVERSITY OF IDAHO

- I. Station: Idaho Agricultural Experiment Station, Moscow, Idaho
- II. Project Title: The improvement of beef cattle through the application of breeding methods: (1) linebreeding within the Hereford and Shorthorn breeds, (2) testing linebred sires within the various lines which will be developed, and (3) determining the relative importance of various reproductive phenomena
- III. Personnel: R. E. Christian, C. W. Hodgson, T. D. Bell, and S. E. Slyter
USDA: R. T. Clark, Coordinator, and C. E. Shelby.
- IV. and V. Nature and Extent of Work Done This Year, and Summary of Progress and Conclusions to Date:

Performance and production data have been collected according to the revised project outline. Calves were weaned at approximately 180 days of age. Following a 28-day adjustment period, 18 bull calves (15 Herefords and 3 Angus) were individually fed for a period of 140 days. The ration used was 1:1 ratio of alfalfa hay and a concentrate mix composed of rolled barley, 39 percent; rolled oats, 39 percent; beet pulp, 20 percent; salt, 2 percent.

The average rate of daily gain for the Herefords was 1.67 lbs. (range 1.46 lbs. to 1.81 lbs.) and for the Angus was 1.57 lbs. (range 1.47 lbs. to 1.74 lbs.). The Hereford bulls required 727.4 lbs. of feed per 100 lbs. of gain and the Angus bulls required 722.8 lbs.

These animals are being continued on a good growing ration and will be made available to breeders in the state.

All heifers from the 1956 calf crop were used in a study of age at puberty in beef cattle. Twice daily heat checks were made with vasectomized bulls, beginning at approximately seven months of age. Frequent rectal palpations were made to check ovarian development prior to puberty. All animals were palpated per rectum after the first heat to determine if ovulation had occurred. The average age at puberty was 353 days for the nine Angus heifers, 378 days for the 16 Hereford heifers, and 383 days for the ten Shorthorn heifers. The youngest animal at puberty was an Angus which came in heat at 243 days; the oldest was also an Angus which came in heat at 418 days. All animals ovulated at first heat. There was considerable follicular development in all animals prior to puberty. Several animals ovulated at least once prior to coming in heat. However, the prepuberal ovulations did not appear to be associated with puberty.

This study will be continued with the females from the 1957 calf crop.

All Hereford cows were palpated per rectum following calving to determine the length of the interval from calving to involution of the uterus and to first ovulation. These data are not complete as yet and will be reported at the annual meeting. Only the Hereford cows were included in this phase of the study this year. However, it is planned to include the Angus and Shorthorn cows next year.

V. Work Planned for the Future:

The production testing program will be expanded to include females as additional facilities become available.

Studies in reproduction will be continued to determine the importance of various reproductive phenomena in beef cattle.

Because of the occurrence of two dwarf calves in the Hereford herd this year, it appears desirable to initiate some work on dwarfism at the Idaho Station (these are the first dwarfs born in this herd for several years). A tester herd of dwarf-carrier females has been assembled and will be used for progeny testing all herd bull prospects before they are used in the main herd.

VI. Publications and Manuscripts:

Christian, R. E. 1957. Age at puberty and related phenomena in the beef heifer. Western Section Amer. Soc. Anim. Prod. Proc. XLII-1.

Cattle Inventory PROJECT SUMMARY Purebreds Idaho Agricultural Experiment Station

Breed	Hereford	Angus	Shorthorn
Station	Main	Main	Main
Bulls (12 mos. or over)	15	5	1
Cows (2 yrs. or over)	51	22	21
Heifers, yearlings	16	9	10
Bull calves	26	6	16
Heifer calves	16	9	10
Percentage used for breeding project	100	100	100
Estimated cash value	\$23,700.00	\$12,250.00	\$11,400.00

Young Animals on Feed Idaho Agricultural Experiment Station
Purebreds

	Hereford		Angus		Shorthorn	
	Number individually fed	Number group fed	Number individually fed	Number group fed	Number individually fed	Number group fed
Bulls	15	-	3	-	-	-
Heifers	-	16	-	9	-	10
Steers	-	11	-	3	-	16

Land, Physical Facilities, and Equipment Used

Item	Actual Cash Value	Percentage Used for Breeding Project
Corrals	\$ 600.00	100
Calf cradle	350.00	50
Portable squeeze chute	500.00	100
Repairs, etc.	2,000.00	100
Bunker silo	1,000.00	100
Pasture renovation	500.00	100

Cow Production Data

Breed	Hereford				Angus				Shorthorn			
Cows bred	43				17				27			
Calves born												
Alive	42				15				26			
Dead	1				0				0			
Total	43				15				26			
Calves weaned	42				15				26			
% calf crop												
Birth	97.7				88.2				96.3			
Weaning	97.7				88.2				96.3			

	Bulls		Heifers		Bulls		Heifers		Bulls		Heifers	
	No.	Ave.	No.	Ave.	No.	Ave.	No.	Ave.	No.	Ave.	No.	Ave.
Average:												
Birth weight	26	69.0	16	69.2	6	63.2	9	65.2	16	66.2	10	65.1
Weaning age	183		183		189		183		184		188	
Weaning weight	26	393.2	16	385.8	6	406.0	9	337.6	15	358.1	10	345.7
Weaning score												
Conf.	26	5.0	16	5.4	6	4.5	9	5.0	16	6.7	10	4.7

MONTANA STATE COLLEGE

- I. Station: Montana Agricultural Experiment Station, Bozeman, Montana, and the North Montana Branch Station, Havre, Montana
- II. Project Title: Recurrent selection and record of performance selection in open and closed beef cattle herds (W-1, M. S. 873, A. I. 104)
 - A. 1. The establishment of inbred lines of registered Hereford cattle, both horned and polled, that will result in improvement in such characters as rate and economy of gain, fertility, nursing ability, longevity, and carcass quality.
 2. The maintenance of an outbred herd of Herefords with bulls selected and furnished by the purebred breeders. The bulls are to be primarily good, high-scoring individuals according to breed association standards.
 - B. 1. The establishment of an improved herd of registered Angus cattle in which the males are selected on a high level of performance as indicated by standard record of performance procedures.
 - C. 1. The investigation of the feasibility of breeding for specific combining ability through recurrent selection.
- III. Personnel:
 - Experiment Station:
 - F. S. Willson, A. E. Flower, E. P. Orcutt, Bozeman
 - J. J. Urick, North Montana Branch Station, Havre
 - U. S. Department of Agriculture:
 - J. R. Quesenberry, U. S. Range Livestock Experiment Station, Miles City
 - R. T. Clark, Coordinator, and C. E. Shelby

IV. Nature and Extent of Work Done This Year:

Bozeman:

The breeding program is progressing in a satisfactory manner as in the previous year. The herd sires selected by the Montana Hereford Breeders' Association and the Montana Angus Breeders' Association to go into the respective herds are very showy animals, but run from 300 to 400 pounds lighter than the R.O.P. bulls we select to go into the R.O.P. herds. The committees are taking a lot of interest in this program.

Corrected weaning weights on the R.O.P. Angus herd are remaining high. Offspring of both sires used in this line exceeded the

weaning weights of show type Angus calves. In addition, the Angus bull calves slightly outgained the show herd Angus bull calves during the feed test (see Table 1).

In the R.O.P. Hereford herd, a mild outcross was tried, but resulted in a reduction in rate of gain as well as score. All bulls but one, and most of the heifers from this mating, were discarded.

Again this year, a weighted, combined ranking was computed for bulls of the Angus and Hereford breeds. Score at close of trial was weighted at 30 percent and yearling corrected weight at 70 percent.

In computing yearling weight, the shrink or gain during the pre-feeding warmup was noted. It was interesting to note that the bull calves of one breed consistently outgained those of the other during this period. This will be observed a second year to check on its validity. If lines consistently differ in reaction to weaning stress, it may well be considered important for selection pressure. Using corrected yearling weight in selection usually would include differences between calves in weaning stress reaction.

We selected at random two bulls from our show type Herefords (Line B) to be bred to a test herd at the U. S. Range Livestock Station at Miles City. This will give us some comparison with existing lines at that station.

In the bull-feeding work, the gains varied from a low of 1.7 pounds per day to a high of 2.85 pounds for the Herefords, and for the Angus, a low of 2.23 pounds to a high of 2.7 pounds. Low-gaining bulls were slaughtered.

We fed the following replacement heifers: 9 Herefords and 6 Angus. Seven Hereford and 5 Angus bull calves were castrated last fall and we are feeding them out to use for judging classes.

Havre:

This was the fifth year of feeding Hereford steer and heifer calves in the recurrent selection trials. This winter 34 steer calves representing seven sire groups were fattened on a standard ration for 196 days and sold locally where carcass data were obtained. Fifty-nine head of crossline heifer calves representing ten sire groups were wintered for 140 days on straight alfalfa hay. The purebred bull calves (20 head) were fed individually on a standard ration for 168 days.

The results of this winter's feeding trial showed slight advantage in daily gain for three crossline groups of steers over the Miles City Line 1 control steers. The difference between the top and low-gaining sire groups in daily gain was not so large this year as during the previous five years. Very little feeding disturbance was encountered this year in any of the sire groups.

Table 1. Bull index (Bozeman) Montana Agricultural Experiment Station

Sire	2	2	2	1	1	2	2	3	1	6	6	6	5	5	5	4	4	
Weighted Combined Rank	4	1	5	8	9	2	6	7	3	5	4	8	6	1	2	3	7	
Relative Index 70-30 Basis	4.7	1.7	4.9	8.1	8.3	2.7	5.1	7.3	3.1	5.3	4.5	7.7	5.7	1.0	2.3	3.4	6.1	
Rank Bull Grade	4	1	7	6	9	2	3	8	5	6	8	7	5	1	3	2	4	
Bull Grade*	78.2	83.2	74.5	76.7	70.0	79.5	78.5	71.7	77.5	76.7	71.5	73.0	77.0	83.8	78.7	81.0	78.5	
Rank Weight for Age	5	2	4	9	8	3	6	7	1	5	3	8	6	1	2	4	7	
Final 12-Month Corrected Weight (Lbs.)	748	860	754	652	678	834	742	731	876	927	933	823	924	1015	942	930	886	
140-Day Daily Gain (Lbs.)	2.03	2.23	2.21	1.70	2.04	2.85	2.14	2.25	2.28	2.60	2.68	2.28	2.70	2.30	2.23	2.48	2.37	
Weight Off Feed (Lbs.)	834	884	797	646	707	876	787	672	747	806	810	800	1009	1019	921	914	905	
Weight on Feed (Lbs.)	550	571	487	407	422	477	487	357	427	460	495	530	680	734	650	610	630	
Corrected Mean.Wt.(Lbs.) (180 Days)	457	530	411	390	354	396	413	380	520	479	438	379	498	519	495	441	371	
Corrected Factor	-123	-52	-71	-15	-56	-79	-72	+30	+100	+69	+28	-56	-69	-71	-49	-59	-107	
Weaning Weight (Lbs.)	570	582	482	405	410	475	485	350	420	410	410	435	567	590	544	500	478	
Birth Weight (Lbs.)	70	72	73	80	70	80	73	70	75	68	70	60	83	72	69	65	58	
Calf Eartag (No.)	500	501	503	517	505	507	508	520	524	428	427	419	413	410	409	408	405	
Cow Age (Yrs.)	9	11	9	5	3	7	4	2	12	5	2	3	6	9	10	10	3	
Cow Eartag (No.)	155	121	160	410	619	208	517	703	110	19	43	46	7	6	40	16	14	
Hereford	1H	2H	3H	4H	5H	14H	15H	16H	17H	Angus	6A	7A	8A	9A	10A	11A	12A	13A

* A. H. Form 522, U.S.D.A.

Sire Key: Hereford

1. Beau Modest 20
2. S.B. Royal Heir 18
3. Clay D Adv. Supreme

Sire Key: Angus

4. Eliminator 89 G.M.R.
5. M.S.C. Bataans F Restorer 2nd
6. M.S.C. Bataans F Prince

1609896
1921764
1790385

7458935
7469665
7389118

In the live animal grading there was a tendency to score few sire groups higher than others. The slaughter grades, however, failed to compare favorably with grades on the rail.

There was a slight advantage in slaughter grade for one crossline group. The others failed to show any advantage over the control group. Carcass grades among all sire groups were quite uniform. One crossline group graded about one-third grade higher than the others on the rail. This was evident by the amount of marbling in the rib-eye of the steers from this group. This year, marbling scores were made on each of the carcasses. Although this was the first year for collecting these data, it is apparent that the federal graders give considerably greater attention to amount of fat in the rib-eye than to external fat cover.

In full feeding, the average gain of bulls was 2.4 pounds with a range of from 2.15 to 2.87 pounds. The high-gaining bull was from the polled line and proved the most efficient. All the bulls were graded by a three-man committee, representing Animal Industry staff. The low-grading animals were disposed of as butcher beef. Two top-performing bulls from each line were retained for testing in breeding herds of randomly-selected grade cows. Surplus bulls of average or above average gaining record with a desirable grade were sold to commercial operators.

The heifer feeding program involved a winter test on alfalfa hay. The crossline heifers were slightly superior in gaining ability on this hay ration. In final score they also excelled. The scores at the end of the winter feeding trial compared favorably with weaning scores.

First calves from two-year-old crossline heifers were compared at weaning time with those from purebred heifers. Crossline heifers produced noticeably heavier calves at weaning and scored higher. In the future, more emphasis will be placed on measuring differences in calf production between the crossline heifers and the purebreds.

Attempts were made to put some surplus crossline heifers out with commercial operators. Several ranchers expressed a favorable viewpoint on cooperating with the station in a breeding program. As yet, definite arrangements have not been made.

Dwarfism has shown up in one of the lines. We are considering procedures to use in correcting the difficulty.

V. Summary of Progress and Conclusions to Date:

There is more evidence of increased interest in this program within and from outside the state. The Montana Performance Registry Association was organized this year. Mr. Orcutt, Extension Livestock Specialist, is secretary. This will help publicize the performance work. It will help the commercial men that have been using high indexed bulls to market their steers at a premium. That, in turn, will bring greater demand on the purebred breeders for feed-lot tested bulls.

VI. Work Planned for the Future:

No great change is contemplated. We brought 46 head of 3- and 4-year-old crossline heifers from the Havre Station to our newly-purchased ranch 32 miles west of Bozeman. We also purchased 16/ head of commercial cows from two ranchers in Park County. We plan on gathering production data comparing the linecrosses with the other group. Three unrelated indexed bulls were purchased to use on these cattle.

We are trying to interest some commercial operators to take some of the Havre crossline heifers so comparisons can be made with other herds.

We hope it will be possible to topcross our two Hereford lines at Bozeman on commercial cows next year.

VII. Publications and Manuscripts:

Dynes, J. R., J. J. Urick, and A. E. Flower. 1956. Carcass characteristics of progeny groups of grade Hereford steers produced in a recurrent selection program. Western Section, Amer. Soc. Anim. Prod. Proc. 7:LXI.

Urlick, J. J., A. E. Flower, F. S. Willson, and C. E. Shelby. 1957. A genetic study in steer progeny groups during successive growth periods. J. Anim. Sci. 16(1):217-223.

Urlick, J. J. 1957. Report of progress: Winter feeding projects, 1955-1956. North Montana Branch Station. Mont. Agr. Expt. Sta. Typed Report.

Willson, F. S. 1957. What's new in livestock and range research in Montana. Mont. Agr. Expt. Sta. Mimeo. C. 99.

Willson, F. S. 1957. What's new in livestock and range research in Montana. Montana Stockgrower. May 1957.

Cattle Inventory
Purebreds

PROJECT SUMMARY
Montana Agricultural Experiment Station
Bozeman

-72-

Breed	Hereford			Linebred		Show Type		ROP		Show Type		Values used at Bozeman: Herd sires at \$550.00, Yearlings at \$400.00
	H.L.1	H.L.2	H.L.3	Hereford	Hereford	Hereford	Hereford	Angus	Angus	Angus	Angus	
Line Bulls (12 mos. or over)	9	16	10		A	B		C	D			
Cows (2 yrs. or over)	15	22	16					9	2			
Heifers, yearlings	5	9	2		19	17		13	12			\$250.00
Bull calves	7	5	5		4	4		5	1			200.00
Heifer calves	5	9	4		10	4		2	3			100.00
Percentage used for breeding project	100	100	100		9	11		11	3			100.00
Estimated cash value	\$7,500	\$10,000	\$200		60	60		60	60			
					\$8,000	\$8,550		\$9,450	\$4,600			

Grades

Breed	Hereford		Havre		Bozeman		None	
	Tester	HL4	63	132	65	54	85	
Line Bulls (12 mos. or over)								
Cows (2 yrs. or over)								
Male calves								
Heifer calves								
Percentage used for breeding project								
Estimated cash value	\$31,000							

Grades

Young Animals on Feed
Purebreds
Bozeman

Montana Agricultural Experiment Station

Grades

Havre

	Number individually fed	Hereford Number group fed
Bulls	9	
Heifers		9
Steers		7

	Hereford Number group fed
	32
	34

Bozeman

	Angus
Bulls	8
Heifers	6
Steers	5

Havre

	Hereford
Bulls	20
Heifers	29
Steers	

Montana Agricultural Experiment Station

Land, Physical Facilities and Equipment Used

Bozeman

Item	Number	Actual Cash Value	Percentage Used for Breeding Project
Beef barn and corrals	1	\$20,000.00	60
Sheds	4	5,000.00	60
Irrigated land	200 acres	80,000.00	100
Saddle horses	2	300.00	60
Miscellaneous equipment		700.00	60

Havre

Bull barn	1	20,000.00	100
Long shed	1	20,000.00	100
Home pasture	1,780 acres	28,000.00	100
Home farmland	200 acres	6,000.00	85
Indian pasture	5,500 acres	55,000.00	100
Truck	1	500.00	90
Saddle horses	7	700.00	90
Scale houses	2	2,000.00	95
Corrals	2 sets	4,500.00	100
Cabins at mountains	2	2,000.00	100
Cattle squeezes	2	400.00	100
Automatic waterers	4	500.00	90

Bozeman

Havre

Havre

Breed Line	Angus		Hereford		Hereford	
	Show type		All grades	HL 1		
Cows bred	12		157	17		
Calves born						
Alive	11		133	14		
Dead	1		8			
Total	12		141	14		
Calves weaned	9		132			
% calf crop						
Birth	91.7		90	82		
Weaning	75.0		84	82		

	Bulls		Steers		Heifers	
	No. Ave.	No. Ave.	No. Ave.	No. Ave.	No. Ave.	No. Ave.
Average:						
Birth weight	5 64.4	1 60.0	5 59.8	81	74	83
Weaning age	238.3	191.0	244.6	189	185	196
Weaning weight	3 471.0	1 210.0	5 409.0	466	426	437
Adj. weaning wt. - 180 days	371.0	201.0	334.0	446	412	408
Weaning score						
Cond.						
Conf.**	3 78.0	1 55.0	5 79.5	81	80	72

* Bred to calve at two years of age.

** A. H. Form 522, U.S.D.A.

Cow Production Data* Montana Agricultural Experiment Station
Havre

Breed	Hereford		Hereford	
Line	HL 2		HL 3	
Cows bred	27		23	
Calves born				
Alive	23		14	
Dead	2		2	
Total	25		16	
Calves weaned	23		14	
% calf crop				
Birth	93		70	
Weaning	85		61	

	Bulls		Heifers	
	No.	Ave.	No.	Ave.
Average:				
Birth weight	78		75	
Weaning age	188		184	
Weaning weight	426		376	
Adj. weaning				
wt. _____ days	412		368	
Weaning score				
Cond.				
Conf.**	78		76	

* Bred to calve at two years of age.

** A. H. Form 522, U.S.D.A.

Breed	Hereford	Hereford	Hereford	Hereford	Hereford	Hereford	Hereford
Line	MC1	HL1 x MC1	HL1 x MC1	HL2 x MC1	HL2 x MC1	HL3 x MC1	HL3 x MC1
Sex	M	M	M	M	M	M	M
Number on test	7	4	4	6	2	5	6
Average:							
Age on test	215	210	206	202	208	215	215
Initial weight	499	488	485	466	523	482	477
Initial score	83	80	83	79	83	79	80
Conf.*							
Days on test	196	196	196	196	196	196	196
Gain							
Total	415	395	408	421	414	421	403
Average	2.12	2.02	2.08	2.15	2.11	2.15	2.06
Efficiency of feed utilization							
Gain/100 lbs. TDN	19.4	19.1	19.2	20.2	20.1	19.5	20.1
Final weight	914	883	893	887	937	903	880
Final score							
Cond.**	12	11	15	13	13	14	13
Carcass grade***	15	15	15	14	17	15	16

* Using A. H. Form 522, U.S.D.A., beef cattle scoring form.
 ** FDA-BAL-ARA No. 101, U.S.D.A., Slaughter cattle grading chart.
 *** FDA-BAL-ARA No. 102, U.S.D.A., beef carcass grading chart.

Feed Lot Performance (Bozeman--Bull Indexing, 140 Days) Montana Agricultural Experiment Station

Breed	Hereford	Hereford	Angus	Angus
Line	R.O.P. Linebred	Show Type	R.O.P.	Show Type
Sex	B	B	B	B
Number on test	4*	5	6**	2
Average:				
Age on test	224.0	265.0	246.8	301.5
Initial weight	403.2	514.4	591.5	620.0
Initial score				
Cond.	77.9	86.3	80.6	79.4
Conf.***				
Days on test	140	140	140	140
Gain				
Total	1,159.0	1,606.0	2,074.0	680.0
Average	289.8	321.2	345.7	340.0
Efficiency of				
feed utilization				
Lbs. TDN/100 lbs. gain, or	482.5	512.0	497.9	510.1
Lbs. gain/100 lbs. TDN				
Final weight	693.0	835.6	897.0	909.5
Final score				
Cond.				
Conf.***	74.0	78.8	76.8	79.8

* One bull was from B herd cow.
 ** One bull was from D herd cow.
 *** Using A.H. Form 522, U.S.D.A.

Feed Lot Performance (Bozeman--Heifers, 140 Days) Montana Agricultural Experiment Station

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Preed	Hereford	Hereford	Angus*	Angus*
Line	R.O.P.	Show Type	R.O.P.	Show Type
Sex	H	H	H	H
Number on test	8	1	5	1
Average:				
Age on test	198.1	256.0	245.6	277.0
Initial weight	357.9	400.0	465.6	560.0
Initial score				
Cond.	77.3	73.3	79.0	88.3
Conf.				
Days on test	140	140	140	140
Gain				
Total	1,509.0		1,021.0	
Average	188.6	210.0	204.2	222.0
Efficiency of feed utiliz ation				
lbs. TDN/100 lbs. gain, or				
lbs. gain/100 lbs. TDN				
Final weight	536.0	600.0	669.8	782.0
Final score				
Cond.				
Conf.**	74.4	82.2	75.4	85.0

* Angus bulls made greater gain almost without exception than did the Hereford bulls during the warmup period.

** A. H. Form 522, U.S.D.A.

UNIVERSITY OF NEVADA

- I. Station: Nevada Agricultural Experiment Station, Reno, Nevada
- II. Project Title: The effect of environment on selection for traits of economic importance, the relative value of several selection criteria, and reproductive studies in range beef cattle
- III. Personnel:
- Experiment Station:
- J. F. Kidwell, H. J. Weeth, V. R. Bohman, D. W. Cassard, J. E. Hunter, C. R. Torell, J. D. Mankin, W. B. Dye, J. A. McCormick, permanent and temporary farm labor, and student assistants
- U. S. Department of Agriculture:
- R. T. Clark, Coordinator, and C. E. Shelby
- IV. Nature and Extent of Work Done This Year:

Experimental animals were managed and routine data collected in accordance with the project outline. All calves were individually fed during a standard 140-day test period. Data include rate and economy of gain, and detailed conformation scores.

It appears reasonable to believe that variation with respect to rate and economy of gain and body size may be the result of variation in fundamental metabolic processes. It is possible that such variation might be reflected, at least in part, by one or more metabolites measurable in the blood at an early age. Glutathione, hemoglobin, blood fat, blood calcium, blood phosphorus, and total cell count have been studied. This year, an experiment was conducted to study the influence of nutritional environment on blood glutathione level in yearling steers. Forty-eight long yearling Hereford steers were assigned treatments for an 120-day feeding period in a 2x2x3 factorial design to determine main effects and interactions of two levels of chlortetracycline, two levels of diethylstilbestrol, and three levels of animal fat, on blood glutathione, hemoglobin, total cell count, weight, rate and economy of gain, and relations among these variables. The data have been analyzed and published. The following conclusions appeared justified:

1. The addition of animal fat, diethylstilbestrol, and chlortetracycline to the ration of fattening long yearling steers has no permanent effect on total blood GSH, hemoglobin, or total cell count, but does influence weight, and rate and economy of gain. Diethylstilbestrol and the interaction of diethylstilbestrol and chlortetracycline resulted in a temporary decrease in blood GSH.

2. Blood GSH, hemoglobin, and total cell count of fattening long yearling cattle are not necessarily stable, but may change rather markedly.
3. There is no correlation between blood GSH and weight, but rather high correlations between GSH, hemoglobin and total cell count exist.
4. Small but significant correlations between blood GSH, hemoglobin, and total cell count with rate and economy of gain exist. The evidence suggests that these do not represent primary cause and effect relations, but are possibly the result of more fundamental metabolic processes mediated through the red blood cells.

During the period 1954-1956, ninety-eight steers were utilized in an extensive study of the relations among conformation scores, body measurements, and production factors. Seventy-one observations were made on each animal. These data were put on punched IBM cards in the University of California computer laboratory. Due to an equipment change they were not able to complete the required analysis. The analysis was made by Dr. C. E. Shelby at the Air Force Finance Center in Denver, Colorado. The analysis and interpretation of these data have occupied virtually all of the time of the project leader and a graduate assistant since early December. A total of seven manuscripts is planned. Data have been analyzed and first drafts prepared for six of these. Publication during the coming year is anticipated.

Wide variation in disposition or temperament of beef cattle within a breed has long been recognized. Many practical breeders believe that rapid gains are associated with quieter, more phlegmatic individuals. Management problems are greatly reduced with more tractable animals. The association of a "wild calf with a wild dam" has been observed by many investigators. There is some evidence that there is a genetic as well as an environmental component of this association. It becomes of interest to study genetic and environmental sources of variation on temperament, and the relation between temperament and rate and economy of gain. The new "tranquilizing" drugs provide a tool for studying behavior. A pilot experiment was conducted to study the effect of meprobamate on the growth of the White Leghorn cockerel. Since this was a preliminary pilot trial, it was independently financed. The data have been analyzed and a manuscript submitted for publication. At the levels fed, the drug had no effect on growth rate.

The pilot experiment with rats to study the effect of environment on selection has progressed well during the past year. A population with maximum genetic variability was established by crossing four inbred lines. Four lines were established from the four-way cross. They included:

1. Standard laboratory ration selected for 70-day weight
2. Standard ration, random selection
3. High roughage ration, selected for 70-day weight
4. Roughage ration, random selected

The fourth selected generation is now approaching 70 days. These data will be summarized and appropriate analysis made during the coming year.

V. Summary of Progress and Conclusions to Date:

A comprehensive, objective summary of the projects progress and conclusions since its inception is difficult.

The acquisition of experimental herds in two locations devoted primarily to breeding research is of some significance, particularly in view of the resources philosophy of the institution. In the early years of the project, most of the effort was directed toward the development of physical facilities. Although at present they are hardly adequate and far short of ideal, they permit the accomplishment of considerable research.

Progress in animal breeding has been modest, and has progressed along several lines. The diversity is the result of the necessity of exploiting opportunities for research as they arose. There were insufficient funds to explore a single problem in detail, ignoring other points. Details of research findings are to be found in the publications cited at the end of this and previous reports and need not be repeated.

The general areas of research that have been investigated include:

1. The number of progeny required to test a male for heterozygosity for a single autosomal recessive gene
2. Muscular hypertrophy and black cutter beef
3. A contribution to the study of dwarfism
4. Phenotypic, genetic, and environmental correlations between growth at different periods in range cattle
5. Beef production from Holstein steers
6. A comparison of group and individual feeding of experimental cattle
7. Hereditary female sterility
8. Bull indexing
9. The relation between conformation and carcass quality in fat steers
10. Compensatory growth of beef cattle
11. Early allometric growth of beef cattle
12. An evaluation of the antipyrene technique
13. The use of blood glutathione as an indicator of growth potential
14. The use of filter paper electrophoresis in dwarf research and in early pregnancy diagnosis

15. The effect of nutritional environment on blood glutathione level in beef cattle
16. A note on progeny tests
17. Evidence of a new lethal gene in cattle
18. Relations between body measurements and conformation scores in yearling cattle
19. Relation between body measurements and production failure in yearling cattle
20. Relations between conformation scores and correlation factors in yearling cattle
21. Relations among conformation scores in yearling cattle
22. Relations among body measurements in yearling cattle
23. Relations among production factors in yearling cattle
24. The influence of meprobamate on growth of White Leghorn cockerels

VI. Work Planned for the Future:

The major future effort is dictated by the project outline. Primarily, the ultimate goal is to study the influence of environment on effectiveness of selection. A second goal is to study selection criteria for traits of economic importance and the relations among them. A review of the literature indicates an urgent need for considering new criteria and for determining genetic relations among them. This will require fairly large populations and specific planned experiments. Studies of growth and form will be continued. An effort will be made to initiate studies of genetic and environmental sources of variation of fundamental metabolic processes affecting growth and development. In general, it is hoped that future work will be of a more fundamental academic nature rather than applied.

VII. Publications and Manuscripts:

- Bohman, Verle, R., and Clark Torell. 1956. Compensatory growth of beef cattle. The effect of protein supplements. (Abs.) J. Anim. Sci. 15(4):1253. J. Anim. Sci. 15(4):1089:1096.
- Kidwell, J. F., V. R. Bohman, M. A. Wade, and J. E. Hunter. 1956. The effect of nutritional environment on blood glutathione level in cattle. (Abs.) J. Anim. Sci. 15(4):1221.
- Kidwell, J. F., V. R. Bohman, M. A. Wade, and J. E. Hunter. 1957. The effect of nutritional environment on blood glutathione level in beef cattle. Growth 21:1-9.
- Kidwell, J. F., and P. R. Ternan. 1957. A note on progeny tests. J. Hered. (In press.)
- Ternan, P. R., and J. F. Kidwell. 1957. Evidence of a new lethal gene in cattle. J. Hered. (In press.)

Ternan, P. R., J. F. Kidwell, J. E. Hunter, C. E. Shelby, and R. T. Clark. 1957. Relations between body measurements and conformation scores in yearling cattle. Western Section, Amer. Soc. Anim. Prod. Proc. 8:LIII.

Ternan, P. R., J. F. Kidwell, J. E. Hunter, C. E. Shelby, and R. T. Clark. 1957. Relations among conformation scores, body measurements, and production factors of yearling steers: I. Relations between conformation scores and body measurements. (In manuscript.)

Kidwell, J. F., P. R. Ternan, J. E. Hunter, C. E. Shelby, and R. T. Clark. 1957. Relations among conformation scores, body measurements, and production factors of yearling steers: II. Relations between body measurements and production factors. (In manuscript.)

Kidwell, J. F., P. R. Ternan, J. E. Hunter, C. E. Shelby, and R. T. Clark. 1957. Relations among conformation scores, body measurements, and production factors of yearling steers: III. Relations between conformation scores and production factors. (In manuscript.)

Kidwell, J. F., P. R. Ternan, J. E. Hunter, C. E. Shelby, and R. T. Clark. 1957. Relations among conformation scores, body measurements, and production factors of yearling steers. IV. Relations among conformation scores. (In manuscript.)

Kidwell, J. F., P. R. Ternan, J. E. Hunter, C. E. Shelby, and R. T. Clark. 1957. Relations among conformation scores, body measurements, and production factors of yearling steers: V. Relations among body measurements. (In manuscript.)

Kidwell, J. F., P. R. Ternan, J. E. Hunter, C. E. Shelby, and R. T. Clark. 1957. Relations among conformation scores, body measurements, and production factors of yearling steers: VI. Relations among production factors. (In manuscript.)

Cattle Inventory PROJECT SUMMARY
Purebreds Nevada Agricultural Experiment Station

Breed	Hereford				
Line	I R	II R	III R	I K	II K
Station	Reno	Reno	Reno	Knoll	Knoll
Bulls (12 mos. or over)	13	11	13	7	7
Cows (2 yrs. or over)	27	33	29	25	30
Heifers, yearlings	9	11	6	8	9
Bull calves	17	14	11	11	14
Heifer calves	7	12	8	9	12
Percentage used for breeding project	100	100	100	100	100

Young Animals on Feed
Purebreds

Hereford	
	Number individually fed
Bulls	41
Heifers	43
Steers	

Grades

Hereford	
	Number individually fed
	48

Land, Physical Facilities and Equipment Used

Item	Number	Actual Cash Value	Percentage Used for Breeding Project
Reno Station - land, etc.	1	\$350,000.00	30
Knoll Creek Station - land, etc.	1	100,000.00	70
Laboratories, equip- ment, etc.		100,000.00	50

Cow Production Data

Nevada Agricultural Experiment Station

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Breed Line	Hereford I R		Hereford II R		Hereford III R	
	Bulls No.	Heifers Ave.	Bulls No.	Heifers Ave.	Bulls No.	Heifers Ave.
Cows bred	12	64	8	76	12	68
Calves born	240	240	240	240	240	240
Alive	12	505	7	502	12	515
Dead	None	None	None	None	None	None
Total	12	78.5	8	76.1	12	77.3
Calves weaned	12	64	8	76	12	68
% calf crop	240	240	240	240	240	240
Birth	12	505	7	502	12	515
Weaning	None	None	None	None	None	None
Average:	12	78.5	8	76.1	12	77.3
Birth weight	12	64	8	76	12	68
Weaning age	240	240	240	240	240	240
Weaning weight	12	505	7	502	12	515
Adj. _____ days	None	None	None	None	None	None
Weaning score	12	78.5	8	76.1	12	77.3
Cond.	12	78.5	8	76.1	12	77.3
Colf.	12	78.5	8	76.1	12	77.3

Cow Production Data

Nevada Agricultural Experiment Station

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Breed Line	Hereford		Hereford	
	Bulls No. Ave.	Heifers No. Ave.	Bulls No. Ave.	Heifers No. Ave.
Cows bred			1 K	II K
Calves born			19	21
Alive			15*	17*
Dead			15	1
Total			15	18
Calves weaned				16
% calf crop				
Birth			79	81
Weaning			79	76
	* 2 illegitimate calves in birth data		* 2 illegitimate calves in birth data	
Average:				
Birth weight	5 69	8 67		
Weaning age	240	240		
Weaning weight	5 328	8 330		
Adj. _____ days	None			
Weaning score				
Cond.				
Conf.	5 74.9	8 73.1	5 72.0	9 73.1

Feed Lot Performance

Nevada Agricultural Experiment Station

Breed	Hereford		Hereford		Hereford		Hereford		Hereford	
Line	1 R		II R		III R		1 K		II K	
Sex	B	H	B	H	B	H	B	H	B	H
Number on test	11	8	9	12	11	6	4	9	6	8
Average:										
Age on test	240	240	240	240	240	240	240	240	240	240
Initial weight	505	448	502	474	515	472	328	330	308	335
Initial score										
Cond.	78.5	76.1	76.8	78.0	77.3	76.9	74.9	73.1	72.0	73.1
Conf.										
Days on test	140	140	140	140	140	140	120	120	120	120
Gain										
Total	2,805	1,600	2,425	2,480	2,660	1,220	904	1,315	905	985
Average	255	200	269	207	242	203	168	146	151	123
Efficiency of feed utilization										
lbs. TDN/100 lbs. gain	-	-	-	-	-	-	-	-	-	-
or										
lbs. gain/100 lbs. TDN	-	-	-	-	-	-	-	-	-	-
Final weight	778	633	775	667	735	657	505	476	458	480
Final score										
Cond.	81.5	82.9	79.6	79.5	77.5	79.9	77.6	76.5	78.7	77.8
Conf.										

NEW MEXICO COLLEGE OF AGRICULTURE AND MECHANIC ARTS

- I. Station: New Mexico Agricultural Experiment Station, State College, New Mexico
- II. Project Title: Breeding beef cattle for southwestern ranges
- III. Personnel:
 Experiment Station:
 R. L. Blackwell and J. H. Knox
- U. S. Department of Agriculture
 R. T. Clark, Coordinator, and C. E. Shelby
- IV. Nature and Extent of Work Done This Year:

The routine collection of production data on the range and purebred herds has continued. Feeding work has consisted of bulls individually fed, type steers group fed, and heifers group fed.

The analysis of a body of data obtained from bulls individually fed was made to study the importance of the effects of (1) inbreeding, (2) adjusted weaning weight, (3) age at the beginning of the feed period, (4) initial weight on test, (5) average daily TDN consumption during the period, and (6) length of feed period on (a) final weight, (b) average daily gain on feed, and (c) TDN required per pound of gain. The principle results of this analysis in terms of partial regression coefficients are given in the following tabulation:

Independent Variables	Dependent Variables		
	Final Weight, Lbs.	Average Daily Gain, Lbs.	TDN Per Pound of Gain
Inbreeding, percent	- 1.59	-.0117**	.0268
Adjusted weaning weight, lbs.	0.08	.0004	.0109
Initial weight, lbs.	0.88**	-.0008	.0033
Initial age, days	- 0.05	-.0004	.0002
TDN/day, lbs.	21.01**	.1583**	.0066
Length of feeding period, days	1.87**	-.0006	.0036
Multiple correlation within subgroups	0.944	0.634	0.381

** Regression significant at .01 percent level of probability

A number of extensive analyses are under way, some of which are nearing completion, that will yield estimates of heritabilities and genetic, environmental, and phenotypic correlations between some important traits of beef cattle. Thirteen traits studied include measures of productiveness on the range and in the feed lot, and some carcass characters. Much of the computational work was done with the aid of IBM facilities available through the office of the Regional Coordinator at Denver. Studies of the effect of inbreeding on these traits, as well as the effect on cow productivity, have been set up with much of the computational work already completed.

Cow productivity expressed as weaning weight of calf has been studied further. Data from a cooperator's herd have been analyzed to determine environmental change from year to year and the change in real producing ability of cows that made up the herd. There were wide fluctuations in environmental conditions, with a small but positive change in real producing ability of cows. This study constitutes an attempt to study the effectiveness of a selection program and breeding plan. In conjunction with this study, estimates of the effects of sex of calf, age of dam, and age of calf were obtained. Presumably, the age of dam effects are free of any selection bias that may have been in the data. The difference between bulls and heifers at weaning was 40 pounds. The regression of weight on age of calf was 1.3 pounds per day, and the amount needed to add to a weaning weight record to adjust for age of dam was 39, 22, 14, 5, 0, 6, 10, and 33 pounds, respectively, for cow ages 3, 4, 5, 6, 7, 8, 9, and 10 plus. The estimate for the "10 plus" group includes 10-, 11-, and 12-year-old cows, and may overcorrect for 10-year-old cows or undercorrect for 12-year-old cows.

A similar study of station data involving a much larger body of data has been started. From the results of these two analyses, further studies will be made of the importance of sires on the calf-producing ability of cows, and the relation between the cow's own weaning weight and her real producing ability for calf production. A preliminary estimate of this later correlation of 0.14 was obtained.

Study of the lethal in the outcross herd is continuing. Additional data on the description of the lethal condition and genetic basis in the station herd have been recorded. Additional matings in cooperation with the Arizona station are being made to determine the genetic relationship between the factor responsible for this lethal condition and that for the "snorter dwarf". At present, cows known to be carriers of the "snorter dwarf" gene are being mated to a bull that has sired lethals in the outcross line in the New Mexico herd.

V. Summary of Progress and Conclusions to Date:

The feeding of the two types of steer calves will be concluded with the current year's work. The data from this work should materially clarify the problems and questions relating to the influence of type on feed lot performance and certain carcass characteristics. The interrelationship between type and other factors of production have

been clarified also, thus making it possible better to understand the effects of selection for different traits on beef production. Weaning weight, one of the more important traits in range beef production, is markedly affected by annual fluctuations in environmental conditions and other environmental influences. Adjustment factors have been derived from data that suitably account for certain fixed effects. Maternal influence is important, but weaning weight per se does not appear to be highly heritable.

VI. Work Planned for the Future:

The research will continue as planned. Analysis of data and publication of results will be emphasized. A new project on meats work will be developed. A portion of this work will contribute to the W-1 effort.

VII. Publications and Manuscripts:

Blackwell, R. L. 1956. Relationship between range characteristics and feed-lot and carcass merit of Hereford steers. Ranch Day (Report). October 8, 1956.

Blackwell, R. L., David E. Anderson, and J. H. Knox. 1956. Age incidence and heritability of cancer eye in Hereford cattle. J. Anim. Sci. 15(4):943-951.

Blackwell, R. L., and Paul Hurt. 1956. Relationship between intensity of red color and performance in Hereford cattle. Western Section, Amer. Soc. Anim. Prod. Proc. 7:IXII.

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Cattle Inventory
Purebreds

PROJECT SUMMARY
New Mexico Agricultural Experiment Station

Breed	Hereford	Hereford
Line	Old Line	Out Cross Line
Bulls (12 mos. or over)	8	10
Cows (2 yrs. or over)	21	23
Heifers, yearlings	7	3
Bull calves	8	4
Heifer calves	4	7
Percentage used for breeding project	65	65
Estimated cash value	\$11,800.00	\$12,500.00

Breed	Hereford	Hereford	Hereford
Line	Big	Medium	Compact
Bulls (12 mos. or over)	0	0	0
Cows (2 yrs. or over)	33	71	30
Heifers, yearlings	2	17	2
Steer calves	12	20	8
Heifer calves	11	21	8
Percentage used for breeding project	50	50	50
Estimated cash value	\$4,225.00	\$11,875.00	\$4,400.00

Young Animals on Feed
Purebreds

New Mexico Agricultural Experiment Station
Grades

	Herefords Number individually fed	Herefords Number group fed
Bulls	21	
Heifers		31
Steers		15

	Herefords Number group fed
	28
	18

Land, Physical Facilities, and Equipment Used

	Number	Actual Cash Value	Percentage Used for Breeding Project
Range land	63,000 acres	\$189,000.00	33
Farm land	52 acres	52,000.00	33
Feed lots		30,000.00	50
Barns	2	120,000.00	70
Meat laboratory	1	100,000.00	10
Pathology laboratory	1	40,000.00	15
Calculators	4	2,800.00	60
Office equipment		600.00	60

OREGON STATE COLLEGE

- I. Station: Oregon Agricultural Experiment Station, Corvallis, Oregon
- II. Project Title: Improvement of beef cattle through breeding methods, using basic genetic and physiological differences in rate and efficiency of gains

Phases of Work

- 1. The effect of such factors as birth weight of calf, suckling gains, age put on test, weight on test, and score on feed-lot performance (Union and Central Stations)
- 2. The effect of the male hormone (testosterone) on rate of gain, feed efficiency, and carcass characteristics
- 3. The development of a selection index for improving beef cattle
- 4. The growth pattern of calves differing in rate and efficiency of gains
- 5. The relation of nitrogenous and carbohydrate constituents of blood and urine to rate and efficiency of gains
- 6. Further studies on heritabilities of production characteristics in beef cattle
- 7. The relation of body scores and measurements to rate of gain, feed efficiency, and carcass characteristics
- 8. Application of selection for greater rate and economy of gains on a ration composed primarily of roughage (Squaw Butte and Central Stations)
- 9. The development and use of inbred lines of beef cattle
- 10. The relation of feed digestibility to rate and economy of gain

III. Personnel:

Experiment Station:

Central Station, Corvallis:

Ralph Bogart, Hugo Krueger, A. W. Oliver, John Kaufmes,
D. A. Price, Hugh Nicholson, G. I. Alexander, R. W.
Mason, Floyd Pahnish, and Earl Ray

Squaw Butte-Harney Station, Burns:

W. A. Sawyer and Robert Wheeler

Eastern Oregon Branch Livestock Station, Union:

James McArthur

Malheur Experimental Area, Ontario:
E. N. Hoffman

John Jacob Astor Branch Station, Astoria:
H. B. Howell

U. S. Department of Agriculture:
R. T. Clark, Coordinator, and C. E. Shelby

IV. Nature and Extent of Work Done This Year:

Calves have been weighed weekly from birth to a weight of 800 pounds, and some to a definite plateau in the slope of the growth curve, to obtain data for developing a mathematical description of growth in beef cattle. The growth curve of the best-gaining and slower-gaining calves will be compared with this standard.

Continued the chromatographic study of blood and urine, concentrating the efforts mainly on the amino acids of the urine.

Correlated the values for blood and urine constituents (creatine, creatinine, urea, uric acid, amino acid, etc.) at 500 and 800 pounds body weight with rate and efficiency of gains, and reported on this at the meeting of the Western Section of the American Society of Animal Production.

Continued the study using rabbits in which the cytoplasmic material, maternal effects both prior to and following birth, and postweaning environments, are held constant with genetics varying. New Zealand does are mated to bucks of Polish (2 to 3 pounds mature weight), New Zealand (9 to 10 pounds mature weight), and Flemish Giant (16 to 20 pounds mature weight) breeding. The young are studied for gains, feed efficiency and body weight, growth curves, and weights of endocrine glands. The study now involves prenatal growth of young of the three genetic groups.

All calves that died or were born dead were examined very carefully for signs of dwarfism; particularly, the head was opened to establish the presence or absence of a hydrocephalic condition.

Cooperated with the extension personnel in profiling bulls to differentiate dwarf carriers from clean ones as a service to breeders. The profiles are taken by the extension men and keyed out in the laboratory.

Scored, measured, and photographed, using a 6-inch grid behind which the animal stands, all animals at 500 pounds when they started on feed test and again at 800 pounds when they completed the feed test.

Individually fed heifers at two levels of TDN intake at Squaw Butte to determine their rates and efficiencies of gain. This will be done for four consecutive years and the heifers will all be kept in the breeding herd. Their calves will be evaluated for rate and efficiency of gains to determine if the genetically superior animals can be

detected on a feed test of roughage feeding or if a higher plane of TDN is necessary. Also, heifers that were individually fed as calves are returned to individual feeding following the summer grazing period to obtain repeatability of performance.

Analyzed data obtained at Squaw Butte over a four-year period when animals were fed at different levels of TDN intake. A manuscript is being prepared.

Continued the development of three lines of Herefords and one line of Angus at the Central Station, selecting for fertility, suckling gains, feed-test gains, feed efficiency, score, and freedom from defects. All animals, both male and female, are feed tested. One line of Herefords is being continued at the Eastern Oregon Branch Station.

Blood samples were taken at 500 and 800 pounds body weight. Hemoglobin, urea, amino acids N, creatinine, and uric acid were determined on all samples. In addition, all samples were examined hematologically. This included red blood cell counts, leucocyte counts, differential counts, and hematocrits.

Some of the calves at 500 pounds body weight and all of the calves at 800 pounds body weight are being analyzed for total inorganic phosphate in whole blood, and for acid and alkaline phosphatase activity in the blood serum.

Plasma proteins in the blood were analyzed by the paper electrophoresis method at 500 pounds, and this is being continued at 800 pounds body weight. Along with this work, the total protein content of the blood plasma and serum has been determined by colorimetric and specific gravity methods.

The method for determining protein bound iodine in the blood plasma of the test calves has been worked out satisfactorily, but more time is needed to establish blood levels of protein bound iodine in different calves.

The herd of beef cattle was bled just after breeding time and the following information on the blood was obtained. Red blood count, leucocyte count, mean corpuscular volume, mean corpuscular hemoglobin, mean corpuscular hemoglobin concentration, and hematocrit, and the plasma proteins, were broken down into the various fractions. This information has not been analyzed.

Biological assay of pituitaries for gonadotropic, thyrotropic, and growth hormone content, has been performed. These pituitaries were from animals receiving low and adequate protein and from animals fed diethylstilbestrol, and their corresponding controls. Day-old chicks were used as the assay animals. Analyses of these data are being made at present.

An inbred line of mice was developed for use in the testosterone work. This line of mice was lost shortly after the testosterone trial started, due to a change in the ration. The new ration was apparently inadequate in that all but nine of the 120 mice died. This has made it necessary to develop a new line of mice for this work, using a new ration.

Using young lactating mice, testosterone was injected at three levels to test the effect of testosterone via the milk. Testosterone propionate and testosterone in aqueous and in oil carriers are being used.

A guinea pig colony in which 20 females litter each month has been developed to provide experimental animals for endocrine studies.

The effect on their offspring of injecting the lactating dams with testosterone has been studied, using guinea pigs and rats.

Using young lactating rats into which testosterone is injected, the effect on their untreated offspring of three levels of testosterone is being investigated. Testosterone in oil carrier is being used.

Testosterone at the rate of 1 mg. per kg. of body weight per week has been injected into guinea pigs during the last 45 days of pregnancy to determine the effects of testosterone on the young during the prenatal, suckling, and postweaning periods.

In cooperation with the nutrition laboratory of the Department of Animal Husbandry, an experiment was carried out with rats to determine the effects of P- deficiency on fertility, endocrine glands, and reproductive organs. The assay will be extended over the microscopic study of these glands and organs, which are preserved in Bouin-fixative.

Collected information on the reproductive performance of two grade Hereford cows which had been injected with testosterone at the rate of 1 mg. per kg. of body weight per week for one year before breeding and for six months of pregnancy; during the first and last two months of pregnancy, testosterone was not given. Observations were made on parturition, lactation, development and growth of the calves, and breeding performance after the cows calved and after testosterone administration had been stopped. Autopsies have been performed on three of the animals involved (two calves and one cow).

The beef cattle records have been reorganized so that all information available on the herd is included. Suckling gains have been calculated for additional animals which were originally omitted from the records, and, for many of these, rate of gain and feed efficiency from 500 to 800 pounds body weight also were calculated. These additional records provided us with complete production records on all cows from 1946 to date. The suckling gains have been analyzed, using between-paternal-half-sibs-within-age-group-of-dam-and-within-year-variation as the error term. The inbreeding coefficient of all calves born has been calculated and a card file of pedigrees of all calves made up.

Investigations of inherited abnormalities in beef cattle and methods of handling them genetically and physiologically are becoming an important part of our program. An Angus bull which appeared to be genetically capable of gaining extremely rapidly but which bloated chronically during the last half of the feed performance test and upon which we felt we did not have sufficient information, was mated to his mother, grandmother, and half-sisters for a progeny test to determine whether his rate of gain or his bloat, or both, were inherited. His calves are now being performance tested. All calves with bloat are recorded, and antibiotics are used to control chronic bloat.

A bull with an extremely poor performance test record was studied by EKG and diagnosed as having an abnormal heart. This bull was mated to yearling heifers from his own and the other two Hereford lines to determine whether the condition is inherited and whether, if it is inherited, the afflicted animals can be handled in a way to make satisfactory market animals from them. The bull was autopsied to relate the EKG findings to actual heart conditions.

Investigated formulae which will provide a "generation" comparison of individuals in a monoparous population such as is encountered in beef cattle where it is impossible to have clear-cut generations. Investigated the possibility of using standard deviations, individual matings, and a constant point of reference as a tool for animal breeding.

Studied the data on all of the beef cattle produced at OSC from the standpoint of the accuracy of correction factors for such characteristics as suckling gains.

Maintained the four strains of mice (A, C, O, and V) by randomly mating and culling, and collected information (number of mice born per litter, total 12-day litter weight, and individual weights at 21, 35, and 45 days of age) on all mice born. These mice are maintained in individual cages.

Maintained and studied six groups of mice with special inherited nutritional requirements.

Started the development of a giant strain (G) and a midget strain (M) of mice by using the utmost selection differential possible in the entire mouse colony. The means of these two groups are at least ten grams apart and there is practically no overlap between the two groups. These groups also serve as guides for other selection experiments.

Developed a colony of mice with one parent a wild mouse. These mice are now being used in a special experiment.

Analyzed data collected on crossbreeding of mice and presented papers on this subject to the Oregon Academy of Science, The Society of Experimental Biology and Medicine, The American Society of Physiology,

The Western Section of the American Society of Animal Production, and The International Society on Fertility.

Continued selection for large and small body size in mice. Mice have been selected for 45-day weight on the individual basis and on the basis of the weight of dam. A group in which breeding stock is selected at random is being used as a control. An additional control also was started this year in which the mice are randomly selected from the other control group. In the first control group, the matings are made individually; in the second control group, all males and females are placed in one large cage during the mating period.

Designed an experiment and provided the mice for Dr. Fox for feeding fresh clover and clover hay to mice to study the effects of the estrogens of these feeds on the reproductive systems of the mice after the feeding trial was over.

Designed an experiment for semen research to study the effects of antibiotics on semen qualities and semen properties.

Electrocardiograms were taken on all Hereford calves at 500 pounds and 800 pounds body weight. Detailed analyses of the electrocardiograms will be made during the summer.

V. Summary of Progress and Conclusions to Date:

The data were analyzed but it was found that if line effects were removed, sire effects also were partly removed and, therefore, negative heritabilities were obtained. If line effects were not removed, the effects of sires contained line effects. Therefore, heritabilities over 100 percent were obtained. This was the result of using only one sire per line in several instances.

The blood constituents studied appear to be related to rate and efficiency of gains, but no one constituent is valid as a means of predicting accurately the production performance of a calf. A combination of several blood and urine constituents may be found useful in the prediction of future performance of a calf. The level of 17-ketosteroids in the urine is related to the level of blood amino acids, which indicates that the adrenal cortex function reduces rate of gain by reducing protein anabolism or by increasing protein catabolism.

The urine-collecting apparatus which has been developed permits us to collect urine from males or females in pens or on pasture over as long a period as may be desired.

The chromatographic studies reveal that certain amino acids are excreted only by the slow-gaining and inefficient animals.

Correlations of various traits involving body scores and measurements, rate and efficiency of gains, and others, show the following:

- (a) Calves that are born later in the season make lower suckling gains, reach 800 pounds at an older age, and are smaller in chest width than those born early in the 90-day calving season.
- (b) Calves heavier at birth gain more rapidly during the suckling and feed-test periods, reach 500 and 800 pounds body weight at younger ages, are more efficient in feed utilization, and score higher for type and conformation at 500 and 800 pounds body weight than the calves smaller at birth.
- (c) Calves which gain more rapidly during the suckling period reach 500 and 800 pounds body weight at earlier ages, are smaller in chest depth and heart girth, and are larger in paunch circumference, and have longer rumps than those which gain more slowly while nursing.
- (d) Calves older at 500 pounds body weight/^{are} the older ones at 800 pounds body weight; have deeper chests but lack in chest width and paunch circumference, and score lower at 800 pounds for type and conformation than the calves younger at 500 pounds.
- (e) Calves which are higher at the withers at 500 pounds are deeper in the chest, and those which are higher at the withers at 800 pounds also are deeper in the chest, have a larger heart girth, and score lower at 800 pounds than those with less height at the withers.
- (f) Calves with greater chest depth at 500 pounds are longer-bodied, and larger in heart girth, and those which are deeper in the chest at 800 pounds also are larger in heart girth and paunch circumference at 800 pounds than the calves with less chest depth.
- (g) Calves that are wider in the chest at 500 pounds body weight have a greater heart girth and paunch circumference and less round but longer rumps at 500 pounds. Those wider in the chest at 800 pounds have a larger heart girth at 800 pounds.
- (h) Longer-bodied calves at 500 pounds are smaller in heart girth and larger in the rump at 500 pounds, make more rapid and efficient gains, have lower height at withers and greater body length at 800 pounds, and score lower at 800 pounds.
- (i) Calves with greater heart girth at 500 pounds have larger paunch circumference and longer rumps at 500 pounds, reach 800 pounds at an older age, and have larger heart girth and smaller rounds at 800 pounds. Those larger in heart girth at 800 pounds have larger paunch circumference and smaller rounds at 800 pounds.
- (j) Calves with greater paunch circumference at 500 pounds have smaller rounds at 500 pounds.

- (k) Calves with larger rounds at 500 pounds gain more rapidly and efficiently, have smaller heart girths and paunch circumferences and larger rounds at 800 pounds.
- (l) Calves with longer rumps at 500 pounds are more efficient feed users.
- (m) Calves which gain more rapidly are more efficient, reach 800 pounds at a younger age, have less width, height and heart circumference, and score higher at 800 pounds.
- (n) The more efficient animals reach 800 pounds at a younger age, are lower in wither height, chest depth, and chest width, and are longer in body and smaller in heart girth at 800 pounds.
- (o) Calves which reach 800 pounds at the older ages score lower.
- (p) Calves that score higher at 500 pounds score higher at 800 pounds.

Data from calves that were fed at different levels of TDN intake each of four years at Squaw Butte warrant the following conclusions:

- (a) Rate of gain is closely related to TDN required per unit of gain. This relationship is curvilinear with a markedly higher TDN requirement per unit of gain when the calves are gaining at a low rate when compared with more rapidly gaining calves.
- (b) Calves that are more severely restricted in feed intake during the winter make slightly greater gains during the summer grazing period but differ markedly in final weight from the more liberally fed calves. Apparently, the feed conditions on this range are not adequate for calves to recover from a growth retardation caused by restricted TDN the previous winter.
- (c) There is some indication that calves within a level of feeding which make more rapid gains during the winter will make more rapid gains during the following summer grazing period.
- (d) There is a linear relationship between TDN intake and rate of gain, with calves receiving more feed gaining more rapidly. It appears that an intake of ten pounds of TDN per day is needed for a gain of two pounds per day.
- (e) Feed efficiency is linearly related to TDN intake, with calves that are receiving more feed making more efficient gains.

The calves that were on test in 1956-57 were quite uniform in rate and efficiency of gain, and in general they were quite good. The David line showed considerable increase in suckling ability and in type and conformation scores. Some difficulty was experienced with fertility in the Lionheart line. Some difficulty with bloat also was encountered, although the feed used this year was prepared in identically the same manner as that which has been used in the past. Average productive merit continues to show improvement.

There was no association between the animal's ability to digest feed and its rate and efficiency of gains under the conditions of this experiment.

Results for the Year:

In the Oregon State cattle, the tendency to bloat is highly inherited, being confined mainly to two lines and to closely related individuals within each line, such as maternal half sibs or full sibs within lines. Some bloat has been found to be associated with disease, whereas other cases seem to be entirely inherited. Particular batches of feed are more bloat-promoting than others.

Some species difference has been noted in response to testosterone. At the same level of injection per gram of body weight, all of the offspring from the rats died within a week of birth, while at the same level of hormone injections the young guinea pigs survived. All of the guinea pigs receiving testosterone injections during the latter part of pregnancy littered normally and no abnormalities appeared in the young.

Correlations were calculated between the data on blood and urine constituents with rate and efficiency of gain in calves' feed tested. In addition, all possible correlations were calculated between blood and urine constituents at 500 and 800 pounds body weight. The former information has been published; the latter has not been written for publication.

Following are some of the more significant correlations:

Amino acid nitrogen in the blood at 800 pounds body weight was significantly and inversely related to rate of gain per day.

Blood amino acid nitrogen was significantly and positively correlated at both 500 and 800 pounds body weight with feed consumed per 100 pounds of gain.

Urea nitrogen levels determined at 500 pounds body weight increased as feed consumed per 100 pounds of gain increased.

Both hemoglobin and uric acid at 800 pounds body weight showed significant, positive relationship to feed consumed per 100 pounds of gain, but at 500 pounds the correlations were not significant.

Creatine levels at 500 pounds body weight exhibited a significant negative relation to feed consumed per 100 pounds of gain, but at 800 pounds the correlations were not significant. No other blood factors were significantly correlated.

Urinary total nitrogen and urea nitrogen at 800 pounds body weight show significant decreases as rate of gain per day increases, but are positively correlated with feed consumed per 100 pounds of gain.

Summary and Conclusions

Four strains of mice (A, C, O, and V) were mated in all possible combinations, each male being mated with a female from each of the four strains. Each male was rotated from female to female at 5-day intervals until all of the four females gave birth to litters, died, or the experiment was concluded after six months. Fertility of the strain and strain-cross matings was measured by the percent of the 5-day mating periods which produced litters, the number of mice born per litter, and the percent of mice born which survived to 12 days of age.

The amount of thyroid tissue per gram of body weight and the relative rate of oxygen consumption, as indicated by gram minutes of survival (body weight x asphyxiation time in a half-pint jar), in the pure strains and in the strain-cross offspring were studied in relation to fertility. Ovarian weight, ovarian activity, and the amount of ovarian tissues per unit of body weight in the parent strains, and the contribution of certain inherited vitamin requirements in the young to fertility also were studied.

Marked differences were noted between pure strains with respect to success of matings, number of offspring born, ability of offspring to survive, thyroid size and activity, ovarian size and activity, and nutritional requirements for fertility.

Sometimes a higher percentage of successful matings above that of both pure-parental strains was obtained when strains were crossed, but in no case was mating success below the less successful of the pure strains. Larger litters were sometimes obtained from the crosses than from the purebreds, and only two crosses yielded an average litter size below the smaller of litter sizes of the two pure-parental strains. In a few of the crosses, a higher percentage of the offspring survived than in either of the pure strains, but in a majority of the crosses a smaller percentage of the young survived than that which survived from either of the pure strains involved.

Thyroid weights of the offspring from crosses were frequently above and also frequently below thyroid weights from pure-strain offspring, and in many cases lay between the values for the pure strains involved. Offspring from the crosses usually were hyperthyroid when compared with either parent strain, in that they survived asphyxiation for shorter periods of time. The hyperthyroid state was marked in all cross strains involving an A strain parent.

All of the four pure strains of mice grew, mated, and reproduced when maintained on the stock diet. However, fertility was so low in the C strain that great difficulty was experienced in maintaining the C colony. The offspring of most of the crosses survived and grew on the stock diet. In some of the crosses, there were difficulties in survival and growth when the offspring were on the stock diet due to altered vitamin requirements.

When V males were crossed with O females, the offspring did not grow because of severe biotin and/or folic acid deficiencies. Growth of the young could be obtained by the administration of folic acid to the mother or to the young. After a satisfactory weaning weight was obtained, further supplementation with biotin and folic acid was not required for survival and subsequent reproduction.

When the A strain was crossed with the other three strains, the offspring grew normally during the suckling period, but failed to grow after weaning. Supplementation of the stock ration with most of the B vitamins restored growth. Folic acid and biotin supplements were not required. Maintenance of mature body weight and survival did not require supplementation of the stock rations, but reproduction required additional supplements of the B vitamins except biotin and folic acid.

Since all mice were in the same laboratory and on the same diet at the same time, the strain and cross-strain difference in mating success, litter size, survival percentages, thyroid weight, unit mass survival time, and vitamin requirements, are mainly genetic. There is a marked interaction between inherited aspects of fertility, including survival of the young, inherited types of endocrine balance, and inherited vitamin requirements.

In some pure strains and crosses, inherited low fertility may sometimes be explained on the basis of an inherited anatomical-physiological-maternal complex somewhat unsatisfactory for survival of the young. In some other cases, low fertility can be explained on the basis of an inherited complex in the young which interferes with survival of the young.

In traits such as growth and survival of the offspring, where heterosis could be studied, usually there was no heterosis or heterosis was negative, rather than the generally accepted concept of positive heterosis or hybrid vigor in the crosses.

Ewes were injected with what were considered to be physiological levels of testosterone both during and following the normal breeding season. Also, young growing heifers and heifers of normal breeding age were injected with testosterone at the rate of 1 mg. per kg. of body weight per week. The effects of injecting testosterone into cattle and sheep following the normal breeding season were an increase in size and function of the pituitary, thyroids, and adrenals, and greater thyrotropin and reduced gonadotropin output by the pituitary. Injections of testosterone into ewes during the normal breeding season did not yield increases in size of pituitary, thyroid, and adrenal glands.

The injections of testosterone into all animals led to masculinization, with changes in musculature, voice, coat color, and reactions to females in heat, increased size of the clitoris, and inactivity of the ovary. Where control heifers and ewes ovulated and had

corpora lutea in their ovaries, the testosterone-treated ewes and heifers showed ovarian inactivity.

Following the injection of testosterone into heifers which were pregnant, there was a lack of relaxation at time of delivery, and reduced labor.

From the results obtained with all the animals used in the study, the following conclusions are drawn:

- (a) Testosterone injections increase thyrotropin and decrease gonadotropin output by the pituitary.
- (b) Animals of the same species differ at different phases of the reproductive stage in their response to injected testosterone. Also, one species may differ from another in response to injected testosterone.
- (c) It appears that animals may develop a mechanism for resisting the response to testosterone.
- (d) Testosterone injections interfere with fertility by causing an inactivity of the ovaries. There is no harmful effect of testosterone on the uterus. The effect of testosterone on the ovaries is neither permanent nor irreparable.
- (e) Injected testosterone apparently passes across the placenta and gets into the circulation of the unborn young.
- (f) Testosterone injections apparently interfere with the production of both relaxin and oxytocin.
- (g) Testosterone injections do not cause irreparable or permanent effects on the mammary gland which would interfere with its function.

Especially important were the findings on calf E40, which had gained weight very slowly but finally reached 1,000 pounds body weight. The heart of E40 at slaughter weighed 3,900 grams (about four times the normal size) and had very thick auricular walls and exceedingly thick ventricular walls. The interventricular septum was perforated whereas the foramen ovale and ductus arteriosus remained widely open. Electrocardiographic potentials were remarkable.

The growth from birth to weaning is linear for each calf, but the slope of the growth curve varies between calves and between lines. Growth from a weight of 500 to a weight of 800 pounds is a linear function of time for each calf, but varies between calves and lines. The sex of the calf influences the slope of the growth curve, with bulls showing a steeper slope than heifers. The slope of the growth curve pre- and postweaning shows only a slight relationship for each calf.

Young mice nursing mothers that had received injections of testosterone showed no alteration in suckling gains unless the mothers had received a quantity which interfered with milk production, in which case the growth of the young was decreased. Following weaning and with the young receiving no testosterone treatment themselves, the young which had nursed mothers that received testosterone grew at a much more rapid rate than the mice which nursed control mothers. At 60 days of age, the mice which had nursed treated mothers weighed 25 percent more than the mice which had nursed control mothers.

The selection with mice for increased and decreased weights at 45 days of age shows that progress downward is more rapid than that in the increased direction. However, the mice selected for increased size appear to be physiologically normal, while those selected for smaller size show increasing physiological disturbances. To establish the basic population from which selection was initiated, crosses of four unrelated strains were made. The crossing of the four strains was done systematically, growth rate and feed consumption being measured for all strains, crosses, and reciprocal crosses. Reproductive performance and efficiency of performance of the F mice also were studied. One cross resulted in mice which show a marked increase in need for folic acid and biotin. This strain cross was quite inferior to the strains which were raised on the stock diet.

Outlook

There is a need for objectively measuring and describing carcass quality so that criteria in the live animal can be related to carcass quality. We need to have some objectivity in our selections for improved meat quality. This important aspect of beef cattle improvement must not be neglected. Without an objective method of measuring meat quality, breeders may tend to ignore this important item in their selection programs.

When does the change in growth to the fattening phase of development occur and what is the relation of the change in the growth pattern to genetically different rates and economics of production?

What is the relation of rate and economy of gain in the feed lot to the performance of the animals on the range?

What changes in body composition accompany selection for rate and efficiency of gains? It would seem that our primary objective in beef improvement is to produce lean meat rapidly and economically. There is a need for determining body composition in the live animal so that selections can be made for the greater production of protein.

Practical Application of Results or Public Benefits

Improvement has been made in rate and economy of gains and suckling ability in all of the four lines at Corvallis in the two generations of cattle covered by the Oregon Station, even though inbreeding exceeding that of half-sib matings has been practiced. The progress in rate of gain has been more striking than that in feed efficiency and suckling gains.

The registered line of Herefords at the Eastern Oregon Station has continued to improve in production while being handled under Eastern Oregon Range conditions. This, plus the significant regression of economy of gain on rate of gain, indicates that a rancher in eastern Oregon can improve both rate and efficiency of gain by weighing calves at birth and weaning and selecting accordingly with very little change in his methods of operation.

Procedures that have been worked out and which are being put into practice by ranchers with the help and guidance of the Extension Service are resulting in marked improvement in beef cattle production throughout the state. At present, 50 breeders are doing production testing.

Several of the factors which influence feed-lot or test performance have been studied so that we now know which ones influence performance most and we can do all possible to properly standardize our test program as the dairy people have done in their dairy herd improvement work. It now appears that the adjustment period of about a month between weaning and feed testing allows the test to be made with a minimum of preinfluence affecting it.

Many practical applications of results obtained may be made from the material that has been put out in published form. One unpublished indication arises from results of the three stations--one using roughage with only a bare amount of concentrate, one using 2 parts of good alfalfa hay to one part of concentrate, and the other using a heavy concentrate-to-hay feeding. It appears that selection for the best-doing animal in each group leads to improvement. This shows that selections for good feed-lot performance can be made from bulls on a ration which will not be injurious to future production of the bulls and heifers because of overfatness.

One basic finding which is important in medicine is that testosterone can pass across the placenta and influence the unborn female young. Since testosterone is used in medical practice in women, it seems very important to recognize that harm might result to a female fetus if the woman were treated with testosterone during pregnancy.

In addition, the Eastern Oregon Branch Livestock Station will breed cows to bulls from the three lines of Herefords at the Central Station and one line at the Eastern Oregon Station to obtain calves from which an evaluation of the relative merit of the four lines can be made. The offspring produced from these matings will be used in other studies but will be so allotted that line and sire effects can be ascertained. The basis for evaluating the lines will be cow productivity of the female offspring and rate of growth of the steer offspring.

The John Jacob Astor Station will use bulls from two of the lines at the Central Station for evaluation of the lines.

Cattle in the hands of farmers where Oregon State College bulls have been used will be studied to obtain some information on the performance of our cattle in commercial herds. Also, we will cooperate with breeders, both as individuals and as groups of individuals, in the keeping of records and in assisting them in selecting their breeding stock.

All of the cattle produced at the Central Station will be photographed, scored and measured at 500 pounds and at 800 pounds body weight. In addition, cows and calves will be weighed weekly until weaning; then, the calves will be weighed each week up to 800 pounds body weight and their weekly feed consumption will be measured.

The Squaw Butte Station will continue the feeding of heifers individually on two levels of intake to determine if selections can be made under a lower feeding regime or if a high rate of feeding is necessary. All heifers will be retained in the breeding herd and their calves will be individually fed to regress performance of offspring and dam. In addition, the heifers that have been individually fed the first winter of their lives and pastured the following summer will be returned to the feed lot and individually fed to determine repeatability of feed-lot performance as measured by rate and efficiency of gains. It is anticipated that a period of four years should give sufficient evidence to direct conclusions relative to the merit of the lines.

Analysis of data for the development of a mathematical description of growth in beef cattle will be continued. Considerable effort will be made to develop a means of describing generation position in our lines of beef cattle since we have in each line cattle ranging from foundation animals to those representing the third and fourth generation of selective breeding.

Studies will be continued on abnormal conditions such as bloat, cancer eye, opaque eyes, dwarfism, and hydrocephalus.

Physiological data will be obtained, including studies on respiration, heart rate, blood pressure, the endocrines, and blood and urine chemistry. Protein bound iodine will be determined and it will be related to rate and efficiency of gains. Also, the electrophoresis of blood plasma will be used as a means of separating the proteins into various fractions. This will be studied in relation to productive performance. Employing the paper chromatography technique, the urine and blood of all cattle will be analyzed to determine the amino acid and ketosteroid metabolism. All of these studies will be related to rate and efficiency of gains. Blood chemistry study will include determinations of uric acid, amino acid N, urea, creatinine, and creatine. A hematology study of all cattle will be made, which will include white cell count, differential count, hematocrit, hemoglobin, corpuscular volume, and corpuscular hemoglobin. Blood inorganic phosphate, serum inorganic phosphate, and acid and alkaline phosphatase activity will be determined on the blood serum of the calves at 800 pounds body weight.

An attempt will be made to determine body composition in live animals by use of heavy water and relate this to productive performance and also to determine factors which do influence body composition.

Data will be analyzed in cooperation with the Regional Office dealing with information obtained at the Squaw Butte Station and the Central Station to facilitate getting information badly needed ready for publication.

The effect of testosterone injected into the pregnant female on the unborn young, its effect when injected into lactating females on nursing young, both during and following the nursing period, and a comparison of different forms of testosterone, will be made.

One factor that will be studied intensively is the passage of testosterone across the placenta and its influence on the genitalia of the unborn young. Another phase that will be studied intensively is the effect of testosterone injections into lactating females on post-weaning performance of the offspring.

The bioassay of pituitary from animals of low and adequate protein intake will be completed.

The selection of mice for increased and decreased size based on individual and on individual + records on relatives will be continued.

The development of a midget strain and a giant strain of mice will be continued and their physiological differences studied. The interrelation of endocrines, nutrition, and genetics in excessive nutrition requirements of certain inbred lines and line crosses of mice will be investigated more thoroughly.

VI. Work Planned for the Future:

It is planned that three lines of Herefords and one line of Angus at the Central Station and one line of Herefords at the Eastern Oregon Station will be continued, with selection on the basis of performance as measured by suckling gain, rate and efficiency of gain, and score from 500 to 800 pounds body weight.

VII. Publications and Manuscripts:

Bogart, Ralph. 1956. Let's have another look at type. Canad. Cattlemen 19(7):9,20-21.

Bogart, Ralph, G. E. Nelms, D. A. Price, C. E. Shelby, and R. T. Clark. 1956. Correlations involving body measurements, scores, and certain production traits in beef cattle. Western Section, Amer. Soc. Anim. Prod. Proc. 7:LVII.

Kaufmes, John, Ralph Bogart, and Hugo Krueger. 1956. Strain differences in hemoglobin, uric acid, urea, amino acids, and creatinine of rabbit blood. Soc. Expt. Biol. and Med., Oreg. Acad. Sci. Proc.

- Kaufmes, John, Hugo Krueger, and Ralph Bogart. 1956. Genetic effects on adrenal, pituitary, thyroid, and body weights of rabbits. Western Section, Amer. Soc. Anim. Prod. Proc. 7:XLIII.
- Krueger, Hugo, Robert Mason, and Ralph Bogart. 1956. Strain differences of thyroids in mice. (Abs.) Amer. J. Physiol. 187(3).
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- Nelms, George E., and Ralph Bogart. 1956. The effect of birth weight, age of dam, and time of birth on suckling gains of beef calves. J. Anim. Sci. 15:662-666.
- Price, D. A., M. A. MacDonald, Ralph Bogart, Hugo Krueger, C. E. Shelby, and R. T. Clark. 1956. Correlations of nitrogenous and carbohydrate constituents of the blood and urine with rate and efficiency of gains in beef calves. Western Section, Amer. Soc. Anim. Prod. Proc. 7:XLIV.
- Bogart, Ralph, R. W. Mason, H. H. Nicholson, and Hugo Krueger. 1957. Genetic aspects of fertility in mice. Internatl. Fert. Assn. Proc.
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- Floyd, Stuart, Frank Hudson, Hugh Nicholson, R. W. Mason, Ralph Bogart, and Hugo Krueger. 1957. Passage of testosterone across mammalian placentae. Oregon Acad. Sci. Proc.
- Hudson, Frank, Hugh Nicholson, R. W. Mason, Ralph Bogart, and Hugo Krueger. 1957. Species differences in effects of testosterone. Oreg. Acad. Sci. Proc.
- Van Arsdell, W. C., III., Robert L. Manning, G. I. Alexander, Hugo Krueger, and Ralph Bogart. 1957. Perforation of ventricular septum in beef calf. Oreg. Acad. Sci. Proc.
- Williams, C. M., Hugo Krueger, and Ralph Bogart. 1957. Nitrogen metabolism as indicated by certain blood constituents of young beef calves.

Cattle Inventory
Purebreds

PROJECT SUMMARY
Oregon Agricultural Experiment Station
Corvallis

Breed	Hereford	Hereford	Hereford	Angus
Line	Lionheart	Prince	David	Angus
Bulls (12 mos. or over)	3	3	3	4
Cows (2 yrs. or over)	22	20	18	21
Heifers, yearlings	1	8	5	13
Bull calves	6	6	10	5
Heifer calves	3	10	2	12
Percentage used for breeding project	75	75	75	75
Estimated cash value	\$9,450.00	\$10,900.00	\$9,250.00	\$12,725.00
Grades	Squaw Butte	Union		
Breed	Hereford	Hereford		
Line	Crow	Chandler		
Bulls (12 mos. or over)	1	3		
Cows (2 yrs. or over)	26	32		
Heifers, yearlings	26	8		
Bull calves	-	6		
Heifer calves	-	19		
Percentage used for breeding project	100	100		
Estimated cash value	\$7,500.00	\$ 7,000.00		

Young Animals on Feed
Purebreds

Oregon Agricultural Experiment Station

Grades

	Hereford Number individually fed	Angus Number individually fed
Bulls	17	7
Heifers	13	14

	Hereford Number individually fed
	28

Land, Physical Facilities and Equipment Used

Item	Number	Actual Cash Value	Percentage Used for :Beef Breeding Project
Feed storage bins	2	\$ 700.00	100
Trailer scale	1	600.00	25
Monroe-matic calculator	1	910.00	100
Trailer	1	1,000.00	25
Loading chute	1	300.00	25

Cow Production Data Oregon Agricultural Experiment Station

Breed	Hereford		Hereford	
Line	Lionheart		Prince	
Cows bred	16*		18**	
Calves born				
Alive	9		12	
Dead	1		1	
Total	10		13	
Calves weaned	7		12	
% calf crop				
Birth	50.0		72.2	
Weaning	35.0		66.7	
* Includes 3 yearling heifers.				
** Includes 2 yearling heifers.				

	Bulls		Heifers		Bulls		Heifers	
	No.	Ave.	No.	Ave.	No.	Ave.	No.	Ave.
Average:								
Birth weight	7	69.3	3	67.0	7	78.0	6	71.0
Suckling gains		1.71		1.87		1.79		1.69
Weaning score								
Cond.*		11.7		12.8		10.4		11.0
Conf.*		10.8		11.4		9.1		10.1

* Ranges from 5 to 15

Cow Production Data Oregon Agricultural Experiment Station

Breed	Hereford	Angus
Line	David	Angus
Cows bred	17*	25**
Calves born	-	--
Alive	12	21
Dead	1	1
Total	13	22
Calves weaned	12	21
% calf crop		
Birth	76.5	88.0
Weaning	70.6	84.0
* Includes 3 yearling heifers.		
** Includes 6 yearling heifers.		

	Bulls		Heifers		Bulls		Heifers	
	No.	Ave.	No.	Ave.	No.	Ave.	No.	Ave.
Average:								
Birth weight	7	68.0	6	60.3	7	66.6	14	56.1
Suckling gains	1.73		1.52		1.73		1.76	
Weaning score								
Cond.*	9.9		9.3		9.8		10.0	
Conf.*	11.5		11.2		8.5		9.5	

* Ranges from 5 to 15

Feed Lot Performance

Oregon Agricultural Experiment Station

*

Breed	Hereford		Hereford		Hereford		Angus	
Line	Lionheart		Prince		David		Angus	
Sex	Bulls	Heifers	Bulls	Heifers	Bulls	Heifers	Bulls	Heifers
Number on test	5	1	6	6	6	5	7	14
Average:								
Age on test	234	224	233	259	241	283 ⁽²⁾	240 ⁽⁷⁾	248 ⁽¹⁴⁾
Initial weight	500	500	500	500	500	500	500	500
Initial score								
Cond.	11.7	12.8	10.4	11.0	9.9	9.3	9.8	10.0
Conf.	10.8	11.4	9.1	10.1	11.5	11.2	8.5	9.5
Days on test	111	147	107 ⁽⁵⁾	130 ⁽⁵⁾	107 ⁽⁵⁾	121 ⁽²⁾	120 ⁽⁶⁾	149 ⁽⁷⁾
Gain								
Total	300	300	300	300	300	300	300	300
Average	2.73	2.06	2.90 ⁵	2.32 ⁵	2.83 ⁵	2.49 ²	2.52 ⁶	2.01 ⁷
Efficiency of feed utilization								
Lbs. TDN/100 lbs. gain:	703	937	621 ⁽⁵⁾	829 ⁽⁵⁾	703 ⁽⁵⁾	833 ⁽²⁾	772 ⁽⁶⁾	1022 ⁽⁷⁾
Final weight	800	800	800	800	800	800	800	800
Final score								
Cond.	11.9	14.2	10.1	12.4	13.0	13.2	9.8	12.4
Conf.	12.0	13.4	11.2	12.6	12.2	12.5	10.6	12.5

Phenotypic Classification of Calves Arranged by Profile Type and by Breeding Tests of Sires and Dams

Proven carrier cows None.Daughters of proven carrier bulls None.

We used only profiled clean bulls. No dwarf or stillborn calves were produced.

U. S. RANGE LIVESTOCK EXPERIMENT STATION

I. Station: U. S. Range Livestock Experiment Station, Miles City, Montana

II. Project Titles:

Narrower only
APH dl-1 Rev. ✓ The development and testing of methods of measuring performance in beef cattle

APH dl-2 Rev. ✓ The development of superior lines of beef cattle

III. Personnel:

U. S. Range Livestock Experiment Station, Miles City
J. R. Quesenberry, R. R. Woodward, and F. J. Rice

Regional Office, Denver
R. T. Clark, Coordinator, and C. E. Shelby

IV. Nature and Extent of Work Done This Year:

1956-57 R.O.P. Bulls--Selected male progeny from 17 bulls were tested. Includes were bulls from nine inbred lines and 13 cross-line matings. All of the latter bulls were the first generation of a new line being formed from crosses of top-producing cows and bulls from the older inbred lines. Three Charollais bulls also were tested this past year. The average daily gain of 79 Herefords was 2.38 pounds per day and for the Charollais 2.44 pounds per day. Ranges in final weight for the Herefords were from 756 pounds to 1,070 pounds. The Charollais were approximately a month older than the Herefords and ranged in weight from 997 to 1,075 pounds.

1956-57 Progeny Test--Sires of the steer calves this year are from lines 1, 5, 9, and 10. Line 1 sires are used most years as a check line. Last year rib samples were shipped to the Meats Section at Beltsville for physical analysis, and tenderness and palatability tests, to supplement the body form measurements and production data that have been obtained for a number of years. It is planned to obtain cut-out values from each steer this year.

1956-57 Calf Production--The range in average daily gain from birth to weaning for the various inbred lines in 1956 was from 1.51 pounds to 2.06 pounds per day. Because of continued low fertility, poor milk production, and mediocre combining ability, the Brae Arden line will be culled this year. This line has been tested in a few line crosses and in an outcross with the grade herd. In this test, completed in 1956, the Brae Arden sire was one of seven sires compared. His steer progeny ranked as follows: average daily gain, 7th, gain per pounds TDN, 6th, slaughter grade, 7th, carcass grade, 2nd. Fertility has been the most serious problem in maintaining this line. For the past two years calving percentages have been below 50 percent.

Pregnancy tests were made on the cow herd just prior to and immediately after weaning in 1956. The accuracy was 97.4 percent.

A paper has been prepared summarizing the occurrence of stillborn calves in the station herd since 1936. The ratio of male to female stillbirths was found to be approximately 1.6:1. Dystocia due to size of calf at birth did not appear to be a major cause of stillbirth. For the period in which weights of stillborn calves have been taken, the range in weight occurring in the normal term of gestation has been 20 pounds to 127 pounds. These weights are approximately 20 pounds lighter and heavier, respectively, than the lightest and heaviest calves born alive. A significantly higher number of heifers had stillborn calves than did cows which had calved one or more times. The stillborn calves appeared to occur quite uniformly throughout the calving season. A more critical study was initiated in 1955.

The second crop of calves from the new "Mixer" line was dropped this year. This line, as reported last year, is being started from the highest-producing cows of all lines mated in all possible crosses to five top sires representing five different inbred lines. The bull calves tested in 1956-57 were above the mean of all lines in gaining ability and only one bull was culled from a total of 17 tested. In all other lines 18 bulls were culled from the 62 that were tested.

Cooperative Study with the University of Wyoming: Approximately 30 heifers have been selected to breed to a proven carrier bull to test the possibility that carrier females can be identified by head form measurements. Head form measurements and profilometer readings have been taken of all 1957 bulls on test and 1956 registered heifers at 6 and 12 months of age. In addition, repeat readings have been taken of the 1955 heifers at 18 and 24 months of age. Preliminary calculations have shown a relatively high association of the zygomatic width measurement at 6 months to 24 months weight. Line differences are evident from the profilometer readings.

Since the last report, the immunogenetic laboratory has typed 79 males and 140 purebred heifers. To date, 442 performance tested males have been typed, as well as 1,100 females, including the purebred cow herd in 1953 and all subsequent registered females as yearling heifers. Earlier analysis revealed no significant relation of blood type of the males to feed-lot performance, although there were some blood type frequency differences when sorted into low, medium, and high performers. A more complete analysis will be made of the entire data. The female data will be used to study the immunogenetic behavior of inbred, crossline, and "Mixer" line matings. Association of relationship studies to blood type frequencies will be studied.

Cooperative Study with F. R. Carpenter, Hayden, Colorado, and Colorado and Montana Experiment Stations: Data from this study, which involves top-cross tests of California and Montana stocks, are now being analyzed.

The cooperative program with Arizona Agricultural Experiment Station at San Carlos Indian Reservation is proceeding as planned.

V. Summary of Progress and Conclusions to Date:

Inbred Lines: With the exception of the Brae Arden line and Lines 11 and 12, formed by line crosses, all lines at this station have been maintained a minimum of nine years.

At the present time only two or possibly three lines appear to show promise of future improvement in performance.

Results at this station appear to indicate that if a line of beef cattle is to be maintained indefinitely it should include sufficient numbers to constitute at least a two-sire line.

Record-of-Performance: The wide variations noted in body form measurements and measures of carcass quality indicate that there is real opportunity for beef quality improvement. Certain inter-relationships between growth, body form, and utility values of the carcass are being investigated looking toward the formation of standards of selection on the hoof which will result in an improved carcass.

VI. Work Planned for the Future:

The line-testing program will be continued. Expansion of the cross-line tests for general combining ability is planned. A short term crossbreeding program using two Charollais bulls on randomized cow herds and unregistered Herefords will be conducted. Crosses involving other breeds are being contemplated.

The carcass evaluation phase of the progeny test program will cover additional items. The physical analysis will be continued in cooperation with the Beltsville laboratory, and data, particularly on the last ten years of carcass work, will be analyzed. Studies on the effectiveness of selection procedures within inbred lines will continue.

VII. Publications and Manuscripts:

Woodward, R. R. 1956. Beef production and carcass quality. Mont. State Col. Beef Production School Mimeo. C. Dec. 1956.

Woodward, R. R. 1956. Breeding systems and cattle improvement. Mont. State Col. Beef Production School Mimeo. C. Dec. 1956.

Clark, R. T., C. E. Shelby, J. R. Quesenberry, R. R. Woodward, and F. S. Willson. 1957. Production factors in range cattle under Northern Great Plains conditions. U.S.D.A. B. (number to be assigned).

Quesenberry, J. R. 1957. Research at the U. S. Range Livestock Experiment Station. Mont. Agr. Expt. Sta. C. 216.

PROJECT SUMMARY
U. S. Range Livestock Experiment Station

Grades

Breed

Hereford

Heifer calves

Young Animals on Feed
Purebreds

U. S. Range Livestock Experiment Station
Grades

	Hereford Number individually fed
Bulls	79
Steers	

Hereford Number group fed	Charollais Number individually fed
56	3

Land, Physical Facilities, and Equipment Used

Item	Number	Actual Cash Value	Percentage Used for Beef Breeding Project
Land			
Buildings, corrals, land improvements, fence, residences, etc.	56,000 acres	\$ 812,500.00	92
		\$2,500,000.00	92

Cow Production Data

U. S. Range Livestock Experiment Station

Breed	Hereford				Hereford			
	Line	No.	Ave.		No.	Ave.		
Cows bred	1	37	83.2		4	49*		5
Calves born	154*	36	181.3		124	1		23
Alive	124	36	181.3		42	43		18
Dead	5	36	414.7		1	41		0
Total	129	36	412.1		43			18
Calves weaned	118	36	414.5		41			17
% calf crop								
Birth	83.2*				89.6*			78.3
Weaning	79.2				85.4			73.9
*5 cow s sold after breeding season. Percentage calf crop figured on 149 cows remaining								
*1 cow sold after breeding season. Percentage calf crop figured on 148 cows remaining								
Average:	Bulls				Heifers			
	No.	Ave.			No.	Ave.		
Birth weight	40	81.6	47	77.3	14	81.0	19	73.1
Weaning age	35	188.3	36	184.1	14	186.1	18	188.8
Weaning weight	35	465.3	47	436.6	14	399.7	18	397.2
Adj. weaning wt. - 180 days			420.0		388.6		383.1	
Weaning score								
Cond.) Comb.	35	7.6	36	6.8	14	7.3	18	7.2
Conf.)								
Average:	Bulls				Steers			
	No.	Ave.			No.	Ave.		
Birth weight	40	81.6	47	77.3	14	81.0	19	73.1
Weaning age	35	188.3	36	184.1	14	186.1	18	188.8
Weaning weight	35	465.3	47	436.6	14	399.7	18	397.2
Adj. weaning wt. - 180 days			420.0		388.6		383.1	
Weaning score								
Cond.) Comb.	35	7.6	36	6.8	14	7.3	18	7.2
Conf.)								
Average:	Bulls				Heifers			
	No.	Ave.			No.	Ave.		
Birth weight	40	81.6	47	77.3	14	81.0	19	73.1
Weaning age	35	188.3	36	184.1	14	186.1	18	188.8
Weaning weight	35	465.3	47	436.6	14	399.7	18	397.2
Adj. weaning wt. - 180 days			420.0		388.6		383.1	
Weaning score								
Cond.) Comb.	35	7.6	36	6.8	14	7.3	18	7.2
Conf.)								
Average:	Bulls				Steers			
	No.	Ave.			No.	Ave.		
Birth weight	40	81.6	47	77.3	14	81.0	19	73.1
Weaning age	35	188.3	36	184.1	14	186.1	18	188.8
Weaning weight	35	465.3	47	436.6	14	399.7	18	397.2
Adj. weaning wt. - 180 days			420.0		388.6		383.1	
Weaning score								
Cond.) Comb.	35	7.6	36	6.8	14	7.3	18	7.2
Conf.)								

U. S. Rango Livestock Experiment Station

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COW PRODUCTION DATA

U. S. RANGE LIVESTOCK EXPERIMENT STATION

Breed	Hereford				Hereford				Hereford			
Line	10				11				12			
Cows bred	26*				22*				17			
Calves born	16				19				16			
Alive	2				1				0			
Dead	18				20				16			
Total	14				19				16			
Calves weaned	85.7*				90.9*				94.1			
% calf crop	66.7				86.4				94.1			
Birth	*5 cows sold after breeding season. Percentage calf crop figured on 21 cows remaining.				*1 cow sold after breeding season. Percentage calf crop figured on 21 cows remaining.							
Weaning												
Average:	Bulls	Steers	Heifers		Bulls	Steers	Heifers		Bulls	Steers	Heifers	
Birth weight	No. Ave.	No. Ave.	No. Ave.		No. Ave.	No. Ave.	No. Ave.		No. Ave.	No. Ave.	No. Ave.	
	5 85.6	3 84.3	7 85.3		5 87.4	5 89.2	9 83.1		4 87.3	3 88.3	9 82.1	
Weaning age	172.0	161.0	5 172.4		192.0	176.2	184.2		186.3	197.0	191.1	
Weaning weight	6** 377.5	3 344.8	5 361.8		5 454.0	5 421.4	9 366.7		4 462.5	3 431.3	9 443.1	
Adj. weaning wt.-180 days	402.6	375.3	379.7		431.2	427.2	360.6		450.8	401.3	422.2	
Weaning score												
Cond.) Comb.	6 7.2	3 6.7	6 6.9		5 7.4	5 6.9	9 5.9		4 7.5	3 7.5	9 7.2	
Conf.)												

** 1 calf not weighed at birth but weaned.

Feed Lot Performance

U. S. Range Livestock Experiment Station

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Breed	Hereford	Hereford	Hereford	Hereford	Hereford	Hereford
Line	1	4	5	6	8	9
Sex	Male	Male	Male	Male	Male	Male
Number on test	35	1	4	4	1	2
Average:						
Age on test	196.3	197.0	202.8	198.8	214.0	202.5
Initial weight	450.0	527.0	435.5	425.8	472.0	464.0
Initial score (Cond. & Conf.)	7.6	8.5	7.5	7.9	8.0	7.8
Days on test	196	196	196	196	196	196
Gain						
Total	16,761	516	1,838	1,766	434	794
Average	478.9	516.0	459.5	441.5	434.0	397.0
Efficiency of feed utilization						
lbs. TDN/100 lbs. gain						
or						
lbs. gain/100 lbs. TDN	22.21	21.95	21.83	21.25	20.87	19.90
Final weight	928.9	1,043.0	895.0	867.3	906.0	861.0

Feed Lot Performance U. S. Range Livestock Experiment Station

Breed	Hereford	Hereford	Hereford	Hereford	Charollais
Line	10	11	12	14	
Sex	Male	Male	Male	Male	Male
Number on test	6	5	4	17	3
Average:					
Age on test	180.0*	200.0	196.8	196.1	-
Initial weight	376.8	450.8	471.5	440.1	545.3
Initial score (Cond. & Conf.)	7.2	7.4	7.5	7.7	-
Days on test	196	196	196	196	196
Gain					
Total	2,803	2,138	1,774	8,042	1,432
Average	467.2	427.6	443.5	473.1	477.3
Efficiency of feed utilization					
lbs. TDN/100 lbs. gain					
or					
lbs. gain/100 lbs. TDN	23.51	19.52	20.54	22.53	21.19
Final weight	844.0	878.4	915.0	913.1	1,022.7

* Figured on 5 head, 1 calf estimated so did not use in this calculation.

U. S. Range Livestock Experiment Station

Phenotypic Classification of Calves Arranged by Profile Type and by Breeding Tests of Sires and Dams

	Number of Progeny											
	Normal Calves			Dwarf Calves			Premature or Stillborn			Died Before 2 Months		
	Sire Classification By Profile	Sire Classification By Profile	Sire Classification By Profile	Sire Classification By Profile	Sire Classification By Profile	Sire Classification By Profile	Sire Classification By Profile	Sire Classification By Profile				
	+ d	++	Int	+ d	++	Int	+ d	++	Int	+ d	++	Int
Proven carrier cows	0	0	0	0	0	0	0	0	0	0	0	0
Daughters of proven carrier bulls												
Daughters of bulls profiled +d												
Daughters of bulls profiled ++												
Daughters of bulls profiled Int												
Daughters of bulls, classification unknown												

UTAH STATE UNIVERSITY OF AGRICULTURE

- I. Station: Utah Agricultural Experiment Station, Logan, Utah
- II. Project Title: The development of breeding techniques and selection criteria for improvement of economically important characteristics in Hereford and Shorthorn cattle
- III. Personnel:
 - Experiment Station:
 - J. A. Bennett, Doyle J. Matthews, Owen Asplund,* A. J. Nyman, and Gren Owens
 - U. S. Department of Agriculture
 - R. T. Clark, Coordinator, and C. E. Shelby

IV. and V. Nature and Extent of Work Done This Year, and Summary of Progress and Conclusions to Date:

Individual performance data on 43 calves were collected during the 168-day test period. An analysis of all data on birth weight, weaning weight, and rate and efficiency of gain in the feed lot, covering a period of eleven years, is being completed. The analysis provides estimates of the relative magnitude of eight components of variation in the aforementioned characteristics. The eight components are: birth weight, age of dam, sex, breed, season of birth, years, inbreeding, and age of calf. A publication containing the results and discussion of the information contained in this analysis is planned for the near future.

The tester herd of known dwarf-carrier cows is being maintained. As in the past, the fastest-gaining, most efficient young bull in the 1956 feed test was mated to this group of cows to prove him concerning the dwarf gene. No dwarf calves were produced in any of the lines in 1957.

Body composition studies were continued in an effort to add refinement to the measurement of efficiency of gains. Antipyrine, tritium oxide, and N-acetyl 4-Aminoantipyrine (NAAP), are being investigated as test substances for use in the estimation of total body water. Studies with antipyrine have shown that it does not entirely fulfill the requisities of an ideal agent to use for the measurement of body water. It is bound to plasma proteins to the extent of about 10 percent. A correction must be applied for the antipyrine metabolized during the period of measurement, necessitating the collection and analysis of three consecutive plasma levels. Determinations based on antipyrine have lacked the consistency that has been desired.

In cooperation with the Atomic Energy Commission and with the Scientific Laboratory at Los Alamos, New Mexico, tritium oxide as an agent for use in body water determinations is being studied. In 1956, fifteen steers were injected with tritiated water. Three of the steers were fistulated and blood and rumen fluid samples were

* On leave at the University of West Virginia.

taken at fifteen-minute intervals for the first twenty-four hours and at various intervals thereafter until the tenth day. The results of these studies indicate that tritium reaches approximate equilibrium in 110 minutes after injection.

There is considerable transfer of tritium to the water inside the rumen. Whether this transfer results from diffusion across the rumen wall or from secretions from the salivary glands, or both, has not been determined. Equilibrium with the rumen fluid occurs approximately 380 minutes after injection. The biological half-life of tritium was found to average 6.4 days in steers. It is clear that estimates of body water, based on blood samples, will be influenced by the transfer of tritium to the rumen fluid. This necessitates the drawing of two or more blood samples at known intervals after equilibrium has been reached, then extrapolating back to zero time. The reading of tritium activity by means of a scintillation counter appears to be highly accurate. If the technique of injecting tritium into the blood stream and correcting for its transfer to the rumen fluid can be made highly accurate, the tritium method offers considerable promise as a means of determining body composition in live cattle.

After the tritium tests were concluded, all steers were slaughtered and fat percentage in the sample area of the 9th, 10th, and 11th ribs was analyzed chemically. Results of these determinations were not highly repeatable due to the extreme difficulty encountered in homogenizing the sample area. Manual separation of fat and lean and homogenization of the separate components increased the accuracy greatly, but further work is contemplated on this phase of the study.

NAAP is now being investigated as an agent for use in the determination of total body water. It has some advantages over antipyrine. In contrast to antipyrine, NAAP is negligibly bound to plasma proteins. The chemical analysis for the compound does not require the use of an ultraviolet spectrophotometer as does that for antipyrine. If NAAP is neither metabolized nor transferred into the rumen fluid, a single blood and urine sample would give all the information necessary to calculate total body water. These problems are being investigated.

Studies were continued on the metabolic by-products of the urine by means of paper chromatography. The spot on the chromatogram formerly designated as the fourteen spot gives further indication that it is associated with dwarfism. The studies this year consisted of attempts to separate the fourteen spot into its components and to study the characteristics of these components. The propylene glycol-methanol-toluene system was developed to separate the steroids which belong to the adrenal cortex group. In the chromatograms, two fluorescent areas were observed other than that at the point of origin. These areas reacted with 2,4 dinitrophenolhydrazine and basic silver nitrate. This, together with their rate of movement on the filter paper, indicated that they were metabolites of cortisone or corticosterone. However, they were found in all the urine

samples studied. The formamide-methanol-benzine system was developed to separate classes of steroid, that is, adrenal steroids from androgens and from estrogens, etc. In this system, a number of fluorescent areas were observed in a variety of patterns. The concentrations of steroid in these areas are very small and several must be combined to get enough for this type of study. Before this can be done, it is necessary to be very careful that all areas combined are identical. Only those with the same R_f and the same color have been used. Area four of the fourteen spot has been consistently different in all cases involving different genotypes concerned with dwarfism. Isolation of the compound and all chemical analysis to date point to the conclusion that it is a steroid from the adrenal cortex. To date it has not been identified as any known substance.

Because of the interest in performance testing among cattle growers of Utah, the Kennecott Copper Corporation has made a grant of \$25,000 to the Utah Experiment Station to construct facilities and to make a testing program available to the cattle breeders of the state. The initial grant covers a period of three years. Many cattle growers have entered bulls in the test scheduled for the fall of this year. With the additional facilities and the increased number of bulls on feed test, the program of developing more refined techniques to measure efficiency will be facilitated.

VI. Work Planned for the Future:

The work will continue as planned for the project. The two lines of Herefords and one line of Shorthorns will be continued with mild inbreeding and selection based on performance.

A considerable effort will be made to establish accurate techniques involving antipyrine, tritium, NAAP, or other materials to be used in the determination of body composition in live cattle.

Identification of dwarf-gene carriers by paper chromatography and related biochemical methods will be continued.

The performance testing of bulls will be expanded to include bulls from many other owners.

VII. Publications and Manuscripts:

Asplund, R. O., J. A. Bennett, and D. J. Matthews. 1956. Observations of glutamic acid excretion in relation to dwarfism and age of cattle. Western Section, Amer. Soc. Anim. Prod. Proc. 7:LXIII.

Shumway, R. P., T. T. Trujillo, J. A. Bennett, D. J. Matthews, and R. O. Asplund. 1956. Fat determination in live steers using tritium injections. Western Section, Amer. Soc. Anim. Prod. Proc. 7:XXIV.

Matthews, D. J., and J. A. Bennett. 1957. Performance testing. Farm & Home Sci. 18(2):40-41.

Cattle Inventory
Purebreds

PROJECT SUMMARY
Utah Agricultural Experiment Station

Breed	Hereford	Hereford	Shorthorn
Line	I	II	
Station	Logan	Panguitch	Logan
Bulls (12 mos. or over)	5	7	8
Cows (2 yrs. or over)	30	47	24
Heifers, yearlings	3	12	6
Bull calves	22	18	12
Heifer calves	6	22	10
Percentage used for breeding project	90	100	90
Estimated cash value	\$10,300.00 : \$16,650.00 : \$10,150.00		

Young Animals on Feed

	Hereford				Shorthorn	
	Line I	Line II				
	No. ind. fed	No. group fed	No. ind. fed	No. group fed	No. ind. fed	No. group fed
Bulls	8	0	5	0	4	-
Heifers	3	0	-	12	6	-
Steers	5	0	6	-	5	-

Land, Physical Facilities and Equipment Used

Item	Number	Actual Cash Value	Percentage Used for Breeding Project
Land - Panguitch	155 acres	\$31,000.00	90
Land - Logan	269 acres	80,000.00	90
Sheds, yards, equipment	4 units	50,000.00	100
Metabolism building	1	35,000.00	10
Maternity stalls, office room at beef unit	2	4,500.00	100

Cow Production Data Utah Agricultural Experiment Station

Breed Line	Hereford		Hereford		Shorthorn	
	Male No.	Female No.	Male No.	Female No.	Male No.	Female No.
Cows bred	47	47	25	25	23	23
Calves born						
Alive	45	45	21	21	20	20
Dead	0	0	3	3	2	2
Total	45	45	24	24	22	22
Calves weaned	42	42	21	21	19	19
% calf crop						
Birth	95.7	95.7	96.0	96.0	95.6	95.6
Weaning	89.4	89.4	84.0	84.0	82.6	82.6
Average:						
Birth weight	18 72.0	27 71.3	15 68.1	6 67.0	10 71.1	10 65.3
Weaning age	184.1	184.1	189.0	189.0	191.1	191.1
Weaning weight	17 351.8	25 353.0	15 394.2	6 342.0	10 432.9	9 400.5
Adj. weaning wt. - 190 days	396.2	416.4	418.3	407.6	452.7	431.2
Weaning score						
Cond.	2.2	2.1	2.5	2.8	2.2	2.3
Conf.	2.1	1.9	1.8	2.0	1.9	1.8

Feed Lot Performance *

Utah Agricultural Experiment Station

Breed	Hereford			Hereford			Shorthorn		
Line	I	M	F	M	S	F	I	M	S
Sex	S						S		
Number on test	5	8	3	5	6	0	5	4	6
Average:									
Age on test	327	222	234	229	325		326	221	236
Initial weight	425	479	390	122	411		554	458	438
Cond.	2.8	2.0	2.3	1.8	2.3		2.6	1.8	2.1
Conf.	2.0	1.6	1.3	2.0	2.2		2.2	1.7	1.8
Days on test	56	168	168	168	56		56	168	168
Gain									
Total	115	372	236	342	119		111	387	236
Average	1.75	2.20	1.40	2.02	1.81		1.76	2.31	1.41
Efficiency of									
feed utilization									
lbs. gain/100 lbs. TDN	30.05	24.80	21.84	24.93	31.10		26.00	24.38	19.73
Final weight	540	850	626	765	529		665	845	674
Cond.	3.1	2.5	2.3	2.6	2.8		2.2	2.5	2.1
Conf.	3.1	2.6	2.3	3.0	2.5		2.2	1.7	2.1

* All animals individually fed.

STATE COLLEGE OF WASHINGTON

- I. Station: Washington Agricultural Experiment Station, Pullman, and Prosser, Washington
- II. Project Title: The improvement of beef cattle by selection and mild inbreeding within lines of the Hereford, Angus, and Short-horn breeds
- III. Personnel:
 - Experiment Station:
 - S. H. Fowler, M. E. Ensminger, and R. D. Setzler
 - U. S. Department of Agriculture:
 - R. T. Clark, Coordinator, and C. E. Shelby
- IV. Nature and Extent of Work Done This Year:

Production Testing WSC Beef Cattle: Fifteen heifers, 4 bulls, and 6 steers from the 1956 calf crop are currently on a feeding trial. The animals are being individually fed on a nonpelleted ration.

At weaning time (approximately 7 months of age), all available heifers (30 head) and all bulls (30 head) were graded as to type by a committee of two. Then, all weaning weights were adjusted by sex to a standard age of 210 days and were adjusted for the age of the dam. All animals' numbers were then arrayed by sex according to type score and adjusted weaning weight. On this basis, the top one-third of the males and the top one-half of the females were selected for the individual feed trials. Six of the males were castrated to furnish carcass data, and the remaining four males were retained as bulls. Some animals were not considered for the individual feeding trial because of markedly inferior type, some because of decidedly low weaning weight, and others because of a combined deficiency in the two traits. Several of the top calves on weaning weight were also top calves on type score.

After a period of 119 days, during which the test calves were self-fed a non-pelleted ration, they were weighed on test and have been hand fed since on a ration that is approximately 80 percent concentrate and 20 percent roughage. The calves are tied to their individual feeders for at least an hour feeding period--once in the morning and once in the late afternoon. The calves will be weighed off test at the end of an 150-day feeding period. At the time they are weighed off test, they will be scored again as to general conformation and type. The top heifers on performance and type will be retained as herd replacements and/or sold to private breeders. The bulls with satisfactory performance records will be made available for sale, and the steers and the low-end of the heifers will be slaughtered to provide carcass data.

A new individual cow performance record card has been compiled for use in the WSC herd. As soon as these cards are available from the print shop, a new card will be completed on each female currently in the breeding herd. These cards will serve as the basis for culling females from the herd.

Individual Testing Programs: Production testing of beef cattle was started as progeny testing in a few purebred herds in the state in 1948, and the present production testing techniques have evolved from the methods used in progeny testing and later work referred to as performance testing.

The statewide program involves cooperation between the breeders, county agents, Animal Science Department, and the extension livestock specialist. The testing program is conducted in three ways:

- (1) Work with individual purebred breeder's feed lot where the entire calf crop of each year is tested,
- (2) Central feed lot tests at fairgrounds, and
- (3) Work with commercial breeders either in selected herds, in large cow outfits, or the entire herd in small outfits where cows are identified and production-tested bulls are used.

The information obtained from individual ranches is as follows:

- (a) A birth weight if possible; if not, an estimated birth weight of 70 pounds is used
- (b) Weaning weights
- (c) Average daily gain from birth to weaning
- (d) Grades of calves at weaning
- (e) Rate of daily gain during a feed-lot test period which normally starts at 7 months of age and is completed at 12 months of age, and
- (f) Grades of cattle at 12 months of age

No attempt is made to keep feed records because this is impossible on a large percentage of the ranches. Since there is a high correlation between rate of gain and feed efficiency, the evaluation is based upon rate of gain.

Selection of females to be added to the herd is made on a basis of giving type and rate of gain equal consideration. The higher gainers of the top grade are selected first. In evaluating bulls, the records are used on the same basis. The better-type bulls making the top gains are selected first. Bulls with low type or inferior gains are eliminated. Good-type bulls with low gains are evaluated lower, and bulls that are somewhat off-type but with good gains are evaluated higher than would normally be true for those types of bulls.

If more than one herd bull is used, a summary is made of each bull's progeny from the standpoint of type and rate of gain.

As females are retained in the herd on the basis of type and gain, accurate records of their production are maintained. This will provide valuable information on expected increases in daily gains, weaning weights, and 12-month weights which may occur over a period of time.

Identifying Characteristics of Economic Importance at an Early Age: Further work is under way to determine the relationship between thyroid activity and gaining ability of cattle through the administration of tracer doses of radio iodine. In addition to supplementing last year's data, additional refinement of the technique is being considered.

All calves in the individual feeding test at WSC will be used in two trials during the course of the feeding test. At each trial, the animals will receive 100 microcuries of I^{131} each. Daily monitoring of the thyroid gland will be made for two weeks to determine the maximum uptake of I^{131} in the thyroid gland and the effective half-life of I^{131} in each animal. In addition, urine will be collected from all males for 24 hours at an interval of 24 hours following the administration of I^{131} , and the amount of excretion of I^{131} will be determined. Maximum uptake of I^{131} by the thyroid gland will be obtained from the 24-hour measurement of I^{131} in the thyroid gland.

It will be determined whether there is a correlation between the hormonal activity of the thyroid gland (as measured by the effective half-life of I^{131} in the animal, the excretion of I^{131} in the urine and the maximum uptake of I^{131} in the thyroid gland) and the performance traits of rate and economy of gain.

V. Summary of Progress and Conclusions to Date:

Production Testing of WSC Beef Cattle: The summary of the performance of 25 animals during the first 84 days of an 150-day individual feeding test is given in the following table:

Summary of Ages, Initial Weights, Average Daily Gains and Feed Efficiency of WSC Beef Calves During First 84 Days of an 150-Day Feeding Test

Number of Animals	Birth Weight (Lbs.)	Ave. Age Beginning Test (Days)	Ave. Wt. Beginning Test (Lbs.)	Ave. Daily Gain (Lbs.)	Lbs. Feed Per 100 Lbs. Gain (Lbs.)
1 Angus bull	54.0	351.0	738.0	1.00	1,279.8
2 Hereford bulls	75.6	338.5	794.0	1.69	781.0
1 Shorthorn bull	67.0	335.0	812.0	1.29	1,254.6
4 bulls	68.0	340.8	784.5	1.42	976.4
3 Angus steers	61.7	343.3	682.0	1.54	890.7
2 Hereford steers	73.0	312.5	649.0	1.67	729.6
1 Shorthorn steer	71.0	343.0	770.0	1.29	1,252.7
6 steers	67.8	333.0	685.6	1.54	883.2
4 Angus heifers	58.9	332.5	674.0	1.34	817.9
8 Hereford heifers	79.0	328.4	685.2	1.50	824.1
3 Shorthorn heifers	65.7	316.0	657.3	1.31	847.3
15 heifers	69.8	327.0	676.6	1.42	826.8

The best animals according to type are not necessarily the best gainers although among the efficient and rapid gainers are animals of good type. It appears that rapid and efficient gains can be attained in beef animals without a loss of conformation or market acceptability. However, it will be necessary to give separate and individual attention to type as well as to feeding performance.

Individual Testing Programs: The field program on production testing is moving rapidly, and the need for more research is becoming increasingly evident each year. The program has proven to be a popular and useful means of initiating and measuring progress in beef cattle improvement because both purebred breeders and commercial cattlemen are interested in increasing efficiency through selection and breeding. Production records now in use show the value of current methods. However, additional research is needed to show the following:

- (1) The best age for selection
- (2) The value of data on the gain over a set period of time (from 7 to 12 months of age in this case) as compared to the time required to gain from a certain weight to another weight
- (3) The degree of heritability of the various economically important traits, and
- (4) The value to give type in evaluating cattle

By giving equal emphasis to type and rate of gain, the program apparently is selecting the better-gaining cattle of a better type. This specific procedure has helped to secure good cooperation and breeder participation. In fact, the program is being well accepted throughout the industry. In view of the fact that data obtained thus far indicate there is no correlation between type and rate of gain, the procedure appears sound. Additional information as to the exact emphasis to place upon type in the evaluation program would be helpful.

It has been found that after a breeder starts the testing program he not only becomes intensely interested in the selection procedures, but also extends his interest far past the genetic aspects. That is, the breeder starts to give more attention to all phases of management, and this is resulting in greatly improved efficiency.

Perhaps the two major limiting factors to the additional spread of the program are: (1) the lack of scales on many ranches, and (2) the shortage of county agent time needed for satisfactory development and supervision of the program. The livestock extension specialist reports that a number of additional breeders throughout the state are ready to initiate production testing work as soon as the county agents have sufficient time to set up the program.

Identifying Characteristics of Economic Importance at an Early Age: The first phase of the I¹³¹ work was initiated on April 28. This first trial has been completed, and the analysis of the data will soon be completed. The second trial is scheduled to begin on June 19. The data for the first trial and possibly from the second trial, will be available for report at the annual meeting of the W-1 Technical Committee in July.

VI. Work Planned for the Future:

Production testing work with the WSC cattle herds will continue, and selection and mild inbreeding will be utilized to accomplish additional improvement. Dr. Clayton C. O'Mary will join our staff as Beef Cattle Production Specialist on July 1, and will aid in the further development of this phase of the program.

If the current trials with radio iodine show promise as a means of identifying rapid and efficient gainers, this work will be pursued further during the coming year in an effort to refine and improve the technique.

With the aid of Dr. E. S. E. Hafez, senior lecturer in physiology, Cairo University, who will join our staff in July on a two year's leave of absence, new approaches to the identification of heterozygous dwarf-carriers will be considered.

In cooperation with the Extension Service, production testing programs will be continued and expanded on individual ranches in the state.

VII. Publications and Manuscripts:

Fowler, S. H. 1956. Selecting cattle for the breeding herd.
Wash. State Col. Dept. Anim. Husb. Stockmen's Handb. 1956:13-16.

Galgan, Mr. W., and M. E. Ensminger. 1956. Raising beef calves from birth on synthetic and whole dried milk, with and without oxytetracycline. J. Anim. Sci. 15:811-819.

Cattle Inventory
Purebreds

PROJECT SUMMARY
Washington Agricultural Experiment Station

Breed	Aberdeen-Angus	Hereford	Shorthorn
Line	1	2	3
Station	Pullman	Pullman	Pullman
Bulls (12 mos. or over)	4	3	3
Cows (2 yrs. or over)	35	23	20
Heifers, yearlings	13	18	11
Bull calves	14	12	9
Heifer calves	12	12	8
Percentage used for breeding project	100	100	100
Estimated cash value	\$30,200.00	\$19,425.00	\$18,250.00

Young Animals and Feed
Purebreds

	Hereford	Angus	Shorthorn
	Number individually fed	Number individually fed	Number individually fed
Bulls	2	1	1
Heifers	8	4	3
Steers	2	3	1

Land, Physical Facilities, and Equipment Used

Item	Number	Actual Cash Value	Percentage Used for Breeding Project
Individual feeders for testing barn	102 acres	\$350.00	100

Washington Agricultural Experiment Station

-141-

Feed Lot Performance (see table in Section V).

UNIVERSITY OF WYOMING

- I. Station: Wyoming Agricultural Experiment Station, Laramie, Wyoming, and Gillette Experiment Station, Gillette, Wyoming
- II. Project Title: Criteria for improving effectiveness of selection in beef cattle
- III. Personnel:
 - Experiment Station:
 - P. O. Stratton, N. W. Hilston, C. P. Stroble, and C. O. Schoonover, permanent and temporary farm laborers, and graduate students.
 - U. S. Department of Agriculture:
 - R. T. Clark, Coordinator, and C. E. Shelby

IV. and V. Nature and Extent of Work Done This Year, and Summary of Progress and Conclusions to Date:

Performance data as called for in the project were collected. Calves were weaned at approximately 180 days of age, at which time they were weighed, scored, photographed, measured, and profiled. After a one-week adjustment, all weaned calves were put on feed test. Four or five of the younger bull calves were castrated at weaning and fed with paired bulls for a comparison of performance and carcass evaluation. The male calves were individually fed and the heifer calves group fed by weight for an 168-day feed period. At the close of the feed test, the same data that had been obtained at weaning were collected on all individuals. In addition, the individuals were bled and blood typed.

Since considerable trouble with bloat was experienced in the pellet feeding at Gillette last year, the trials in 1956-57 were designed to study the effect of different rations on performance and the incidence of bloat. Alfalfa, alfalfa and native, and native hay for three different rations were used as the roughage part of the 1:1 mixture fed this year. The cost per ton of Ration I, II, and III was \$63.35, \$67.50, and \$73.00, respectively. Twelve bulls were randomized by age into three treatments and fed individually twice daily. Eighteen heifers were randomized by age into the three treatments and group fed by treatment. The ration was fed for 154 days in a 3/8-inch pellet form. Ration I was identical to that ration used in last year's study. There was considerable bloat in all treatments again this year; however, the incidence or prevalence of bloat in any lot was not as high as last year. One chronic bloater fed Ration I gained very poorly and one bull fed Ration II died of bloat during the second week on feed test. The bulls on Ration I, II and III gained 1.78, 2.04, and 1.60 pounds per day on 346, 402, and 429 pounds of T.D.N. per 100 pounds of gain, respectively. The total feed cost per 100 pounds of gain was \$17.51, \$21.53, and \$24.33, in order. There was no significant difference in gain for the three treatments. The heifers were group fed, and gain this year had decidedly less incidence of bloat than the bulls. They did much better

on test as measured by bloom and thriftiness. One heifer in each of Lots I and II died of bloat late in the feed test. The average gains by treatment for the 154-day trial were 1.74, 1.63, and 1.65 pounds, respectively, and the average feed costs per 100 pounds of gain were \$26.34, \$28.07, and \$30.00, respectively. There was no significant difference of gain between treatments. Of the 16 head (9 males and 7 females) slaughtered at the meats laboratory in Laramie, only one animal had an abscessed liver. All animals had access to free choice salt and bone meal with hi-amine added.

Head form studies on Hereford females have continued. Repeat studies on the 1954 and 1955 Miles City purebred heifers were taken at 18 and 24 months of age. In addition, head form data on the 1956 heifer crop at 6 and 12 months of age were taken of the Miles City purebred heifers, University of Wyoming Hereford heifers, and heifers from a herd in the western part of the state. These data will be studied for any association with dwarfism and/or performance. A breeding test has been designed whereby a group of heifers selected on head form will be mated to a known carrier bull this breeding season at Miles City. The lack of dwarfs in the lines has given little to work with regarding carrier females.

To aid in our state performance testing program, four years of data on 185 calves were analyzed to estimate birth weight from heart girth measurements. The following table includes the results by breed:

Estimation of Birth Weight of Beef Calves by Heart Girth Measurements

Heart Girth (In.)	Expected Birth Weight in Pounds			
	Hereford (Lbs.)	Shorthorn (Lbs.)	Angus (Lbs.)	Combined (three breeds) (Lbs.)
23.0	47.4	42.0	36.4	41.2
23.5	49.6	45.1	39.4	44.0
24.0	51.9	48.1	42.4	46.8
24.5	54.1	51.2	45.5	49.5
25.0	56.4	54.2	48.5	52.3
25.5	58.6	57.3	51.6	55.1
26.0	60.9	60.4	54.6	57.8
26.5	63.1	63.4	57.7	60.6
27.0	65.4	66.5	60.7	63.4
27.5	67.6	69.6	63.7	66.2
28.0	69.9	72.6	66.8	68.9
28.5	72.1	75.7	69.8	71.7
29.0	74.4	78.4	72.9	74.5
29.5	76.6	81.8	75.9	77.3
30.0	78.9	84.9	78.9	80.0
30.5	81.1	87.9	82.0	82.8
31.0	83.4	91.0	85.0	85.6
31.5	85.6		88.1	88.3
32.0	87.9			91.1
32.5	90.1			93.9

These values were determined from data collected on the beef herd at the University of Wyoming. They should be used only when birth weights cannot be obtained by the use of a scale, never in preference to actual weights. A snug, but not tight, measurement is suggested.

The immunogenetics laboratory has processed blood samples from 361 animals this past year. Included were bulls from Laramie, Gillette, and Miles City, to determine the association of blood type and feed-lot performance. The remaining data have come from females at the three stations to be studied in connection with the immunogenetic behavior of inbred lines. The mating system at Gillette has been directed as an aid to this problem. The laboratory has developed 46 iso-immune cattle sera, 4 heteroimmune sheep sera, and 27 heteroimmune rabbit sera.

Meats Work: We have observed at this station that some rib-eye areas of 12- to 13-month-old bulls compared favorably to the rib-eye area of steers slaughtered at 20 to 25 months of age. To study this observation, five to six bull calves of each breed were castrated at weaning, then fed individually with the remaining bull calves for a comparison of gains and carcass evaluation. The bulls consistently outgained the steers on less feed per 100 pounds of gain. Paired slaughter tests of bulls and steers are being conducted. Also, three bull calves were castrated at the end of the feed test, and carcass comparison will be made next winter with some steers castrated at 6 months of age.

In an attempt to measure objectively and describe carcass quality, a test for cell size in fresh muscle tissue has been initiated. Most of the effort to date has been directed toward technique. Sample tissue taken by the core method from the round of the beef carcass was studied. The best results have been obtained when the fresh tissue was immersed in a sugar solution for a short time before sectioning with the freezing microtome. The sugar solution does prevent a minimum of cell distortion.

This year the complete separation of lean and fat tissue on full sibs--a steer 24 months of age and a yearling bull--was made. The results of this comparison were as follows:

	24 Months	12 Months	Percent Increase 24 Mos. over 12 Mos.
1/2 hot carcass weight (lbs.)	326.5	175	187
Total lean (lbs.)	177	119.5	148
Total fat (lbs.)	79	20	395
Total bone (lbs.)	42	29.5	142

Sixty pounds of fat were stripped from offal of the older animal and the remaining fat was at least as much as that which was present in the offal of the younger. Plans for the coming year are to use three sets of identical twins located near Laramie for a more thorough study. Slaughter will be at different stages of growth and age. The experiment will be a paired study design.

Frequently, breeders and feeders mention that meatier animals are heavier boned. Usually, they are estimating bone by the size of cannon bone. Work from New Zealand has indicated that meatiness can be estimated with 90 percent accuracy by the weight of the cannon bone. To test this theory, cannon bones of all animals slaughtered in the Laramie Meats Laboratory have been saved to make further studies. Weight, length, width, and the ratio of length to width of the cannon bone are being studied. The association of these values to carcass meatiness, weight, rib-eye area, etc., will be studied.

Radiographs of the cannon bone of all 1957 calves have been taken as a possible tool for the detection of dwarfism, and for the prediction of growth rate and stature of the animal after weaning. Subsequent readings will be taken at weaning and postweaning feed tests. These results will be compared to actual cannon bone analysis when and if the animals are slaughtered.

The development of meat-type cattle would be greatly aided by a practical and accurate in vivo determination of carcass composition. The association of blood serum creatinine level to lean in the carcass has been studied. Serum creatinine levels were obtained from 35 cattle. Carcass composition was estimated by a photographic measure of the rib-eye area and a densimetric determination of the percentage of lean in the boned 9th, 10th, and 11th rib cut.

Serum levels of creatinine were found to be significantly related to percentage of lean in the boned 9th, 10th, and 11th rib cut ($r = +.55$, $n = 35$) and rib-eye area corrected for carcass weight ($r = +.52$, $n = 27$). Although the above correlations were highly significant, the predictions by serum creatinine were low, $r^2 = .27$, and $r^2 = .31$. Thus, 73 and 69 percent of the variation in carcass lean, as estimated by rib-eye area and percentage of lean in the rib cut, respectively, was not accounted for by differences in serum-creatinine levels.

The relationships between the estimates of carcass composition were highly significant. The correlation between corrected rib-eye area and the percentage of rib-cut lean was $+ .79$. The area of external fat and the area of rib-eye measured from colored photographs were used to estimate the proportion of lean. The correlation between this estimate and the densimetrically-determined proportion of lean in the boned 9th, 10th, and 11th rib cut was $+ .94$. The data indicate that this photographic estimate could be used as an accurate estimate of carcass composition.

VI. Work Planned for the Future:

The work will continue as planned in the project. Body measurement data are now being analyzed for an M.S. thesis. Some variation in TDN and net energy requirement for feed-lot testing will be studied next year.

A majority of our efforts will be directed toward carcass studies. Our data have been accumulating for three years and standardization of the data will lend itself to more accurate analysis. The direction of our efforts will be governed by these results as they are obtained. Basically, our breeding plans will be directed as much as possible in an attempt to improve objectively meat quality and economy of meat production. There already appears to be a decided change in body conformation or type, and we feel the final product should govern such.

Head form studies will be summarized in a Ph.D. thesis this summer. The continuation of this work will be governed by the results obtained.

Radiographic determination of cannon bones will yield some results by our next meeting. Should this indicate promising results, greater emphasis will be directed toward this phase of the project.

VII. Publications and Manuscripts:

Kercher, C. J., P. O. Stratton, C. O. Schoonover, N. W. Hilston, M. W. Glenn, and E. J. Thiessen. 1956. The effect of feeding stilbestrol on the performance and carcasses of steers. Western Section, Amer. Soc. Anim. Prod. Proc. 7:XXXI.

Stratton, P. O., N. W. Hilston, and C. O. Schoonover. 1956. A study of duplicate head form measurements on horned Hereford bulls at different ages. Western Section, Amer. Soc. Anim. Prod. Proc. 7:LXIV.

Wymore, Richard M. 1956. The use of indicator methods in determining the digestibility of forages. M. S. Thesis. University of Wyoming.

Schoonover, C. O. 1957. Cutting the beef carcass. Wyoming Roundup 5(1).

Schoonover, C. O., and P. O. Stratton. 1957. A photographic grid used to measure rib-eye area. (In manuscript.)

Wuthier, Paul R. 1957. The creatinine level of blood serum as an indicator of carcass composition. M. S. Thesis. University of Wyoming.

Wuthier, Paul R., and P. O. Stratton. 1957. The creatinine level of blood serum as an indicator of carcass composition. Western Section, Amer. Soc. Anim. Prod. Proc. 8:LII.

Cattle Inventory

PROJECT SUMMARY
Wyoming Agricultural Experiment Station

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Breed	Hereford	Hereford	Shorthorn	Angus	Hereford
Line	Laramie	Gillette	U.W.	U.W.	Dryer
Station	Laramie	Gillette	Laramie	Laramie	Laramie
Bulls (12 mos. or over)	2	3	4	4	1
Cows (2 yrs. or over)	28	35	25	27	12
Heifers, yearlings	4	9	6	5	1
Bull calves	13	16	15	5	8
Heifer calves	12	4	10	21	4
Percentage used for breeding project	100	100	100	100	100
Estimated cash value	\$10,900.00	\$10,100.00	\$10,900.00	\$10,000.00	\$4,000.00

Young Animals on Feed

	Hereford	Angus	Shorthorn	Grades
	Gillette	Laramie	Laramie	Individually fed
Individually fed	Individually fed	Individually fed	Individually fed	Individually fed
Bulls	8	2	12	8
Heifers	18	9	7	23
Steers	3	1	3	2

Land, Physical Facilities and Equipment Used

Item	Number	Actual Cash Value	Percentage Used for Breeding Project
Tractors (lease)	4	\$1,951.75	50
Forage harvester (lease)	1	448.14	70
Plow (lease)	1	64.44	70
Manure spreaders (lease)	2	100.69	80
Trucks		1,632.36	60
Beef equipment		260.16	100
Office equipment		760.77	60
Meats laboratory equipment		1,106.63	90
X-ray equipment		34.25	90
Hereford bull		300.00	100
Corrals		151.26	90

Cow Production Data Wyoming Agricultural Experiment Station

Breed	Hereford	Grade Hereford
Line	Gillette Hereford	Dryer Hereford
Cows bred	34	10
Calves born		
Alive	30	10
Dead	4	0
Total	34	10
Calves weaned	30	10
% calf crop		
Birth	100	100
Weaning	88.2	100

	Bulls		Heifers		Bulls		Heifers	
	No.	Ave.	No.	Ave.	No.	Ave.	No.	Ave.
Average:								
Birth weight	14	68.5	20	68.0	6	73.3	4	73.8
Weaning age	152		170		174		166	
Weaning weight	12	287	18	310	6	357	4	295
Adj. weaning wt. - 180 days	315		324		365		318	
Weaning score								
Cond.	12	3.33	18	4.44	6	4.17	4	3.50
Conf.								

Feed Lot Performance*

Wyoming Agricultural Experiment Station

Breed	Hereford				Angus				Shorthorn				Gillette Hereford		Grade Hereford		
Line	U.W. Hereford				U.W. Angus				U.W.Shorthorn				Gillette Hereford		Dryer Hereford		
Sex	M	S	F		M	S	F		M	S	F		M	F	M	S	F
Number on test	9	4	7		8	4	9		9	4	7		11	16	3	1	4
Average:																	
Age on test	194	162	189		200	174	193		192	179	191		187	208	199	171	176
Initial weight	391	364	383		420	340	380		431	393	379		302	316	425	290	309
Initial score																	
Cond. (Comb.)	4.3	5.3	4.8		5.2	4.8	4.2		4.8	4.5	4.3		3.5	3.6	5.0	2.33	2.8
Conf.																	
Days on test	168	168	168		168	168	168		168	168	168		154	154	168	168	168
Gain																	
Total	3051	1124	1708		2344	984	2061		3132	996	2072		2843	4123	936	345	1156
Average	339	281	244		293	246	229		348	249	296		259	268	312	345	289
Efficiency of feed utilization																	
Lbs. TDN/100 lbs. gain **	472	531	667		530	596	676		504	657	554		392	527	538	554	509
Final weight	730	645	626		708	599	609		778	641	675		561	584	737	750	598
Cond. (Comb.)	4.1	3.8	4.4		5.0	3.3	4.7		5.3	2.8	4.7		3.4	4.2	2.7	4.0	2.3
Conf.																	

* Heifers group fed by sire group. Bulls individually fed.

** Ration 1:1

Alfalfa - 225 Oats - 50
 Barley - 100 Corn - 50
 Wheat bran - 25

Wyoming Agricultural Experiment Station

Phenotypic Classification of Calves Arranged by Profile Type and by Breeding Test of Sires and Dams

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	Normal Calves			Dwarf Calves			Number of Progeny			Died Before 2 Months		
	Sire Classification By Profile			Sire Classification By Profile			Sire Classification By Profile			Sire Classification By Profile		
	+d	++	Int	+d	++	Int	+d	++	Int	+d	++	Int
Proven carrier cows												
Daughters of proven carrier bulls			7									
Daughters of bulls profiled +d												
Daughters of bulls profiled ++			4- 5						3			1-
Daughters of bulls profiled Int			3- 14+						1+			2**
Daughters of bulls, classifica- tion unknown			5* 8									1

Sires - Laramie 636
Gillette 67**
183+
155*
(245)

The chairman called for the state reports. Several committee members expressed the view that these presentations should consist of any necessary amplification of the reports that had been circulated before the meeting, a question and answer period, and constructive criticism.

The various state reports were presented and all committee members participated in the discussions which followed.

Business Meeting

Thursday, July 18, 1957 - 8:00 A.M.

The meeting was called to order by the chairman, J. F. Kidwell.

Flower introduced the topic of standardizing methods of computing calf crop. The prime necessity of each state illustrating clearly the method used in reporting calf crop was emphasized in the discussion which followed.

Dr. Bogart brought up the desirability of holding another workshop in conjunction with the next W-1 meeting. Several committee members expressed themselves in favor, and Gregory inquired where the next meeting would be held.

Pahnish extended an invitation from the University of Arizona to meet in Tucson next year.

Discussion took place on the time of meeting, especially in relation to workshop facilities and program to be offered.

Bogart moved acceptance of the invitation of the Arizona station to meet in Tucson next year. Gregory seconded the motion. Motion carried.

Wayman moved it be left to the Executive Committee to determine the time of the 1958 Technical Committee meeting, considering the interest of the majority of the committee members who attend the Western Section meeting. Bogart seconded the motion. There was further discussion on the time of meeting. Motion carried.

Stonaker moved that a workshop be planned for next year. Bogart seconded the motion. Motion carried.

Kidwell posed the question, what kind of workshop? Stonaker suggested that the workshop consist of a seminar, but that each participant bring his own problems to work on. Kidwell said most people need help on fundamentals. Bogart suggested a two-level workshop--people with their own data working on newer statistical methods, and some of these people in turn helping others on the routine techniques.

Kidwell suggested the workshop should not be restricted to simple statistical techniques, that there should be some biology. Gregory was intrigued by Kidwell's suggestion and said our group lacks broad biological concepts. Before statistical techniques were developed, biology and genetics went hand in hand and the early investigators did a good job. Nowadays, in applied genetics programs, biology has been pretty well disregarded and in place of classical genetics there has been substituted a statistical approach. Often, the conclusions can not be integrated with biology or any biological principles and, thus, are meaningless. Evidence of this can be seen in a good many of the problems we are dealing with which have a real bearing on our research programs. Some of these broader biological concepts should be given consideration in our workshop program.

Bogart suggested two areas of work, genetic-nutritional interactions and genetic-endocrine interactions.

Gregory referred to the development of lines as part of the work program and stated that there is no known mating system or means which will assure the maintenance of genetic constancy within a line. If this could be attained in domesticated animals, it would represent the greatest contribution we could make.

Wayman suggested a standardization of procedures between stations, making it possible to pool results and achieve a truly regional project. During the workshop all the work of the region could be brought together.

Wheeler expressed the hope that the workshop at some future time might be helpful in leading the way toward some type of regional publication that would tap the whole regional effort. W-1 has been very productive and has a tremendous mass of published material through individual manuscripts, but a regional publication could lead to wider acceptance of the principal research accomplishments.

Burris conveyed the views of State Experiment Stations Division in this connection. Wheeler illustrated how regional publications could be financed, and stated that this problem is not insurmountable. And since W-1 is the "grandpappy" of these regional projects, there is an obligation to give a good account of where we have been, where we are, and where we are going. The preparation of the regional publication will be a much greater task than the publishing problem.

Stonaker stated that a great deal of the W-1 material was incorporated in the Literature Review (Arizona) and could be pulled out for this purpose. He raised the question of how this Literature Review could receive wider application.

Warwick posed the question of whether the publication would be something of a technical nature. Wheeler said not necessarily. The experts would have to interpret the technical information into a form that would be readily understood by the cattlemen. Gregory referred to the job that was done in summarizing research results in the 1936

and 1937 Yearbooks of the U. S. Department of Agriculture. Warwick asked if publications of this sort should be separate for each region. There are advantages and disadvantages. Bogart said the first effort should be on a regional basis with the entire committee contributing in the area of research in which each committeeman is strong; that the publication should be prepared with rancher appeal in mind, yet carry scientific material as well.

Stonaker reviewed his experience over four years on a similar committee assignment and stated that so far it has been unproductive. He thought one man should take on the responsibility, but if a controversial topic is to be covered it should be prepared as a controversial subject. Bogart emphasized his opposite experience, that a committee can work this out provided it is well organized.

The committee returned to consideration of the nature and extent of the workshop program. Bogart proposed that during the Tucson meeting one day be given to the W-1 business meeting, one day for Extension, and three days for workshop. Stratton, Bennett, Stonaker, and Gregory agreed that five days would be sufficient.

Bogart moved that a committee be appointed to plan the workshop. Gregory seconded the motion. Motion carried. Kidwell said the new chairman will appoint the committee.

The committee then returned to the topic of a regional publication. There was considerable discussion by most of the committee regarding the possibility of a publication which would be useful to Extension as well as research workers.

The meeting recessed at 10:00 A.M., and reconvened at 10:15 A.M.

Kidwell called on Stratton to present his ideas on the matter of publications.

Stratton moved that each station send what information and publications it has to the Denver office and that a more or less technical bulletin or summarization of the work be compiled by Dr. Clark and this review sent to the W-1 Technical Committee members for criticism and correction, this probably being the quickest and most desirable way of preparing a publication. Stonaker seconded the motion.

In a discussion of the motion Woodward, Wheeler, Kidwell, and Stonaker saw no reason why general recommendations based on the research results could not be drawn. Stratton expressed the view that the coordinator's office is the place for summarizing the work of the W-1 project. Discussion by Bogart, Warwick, Kidwell, Stratton, Stonaker, and Gregory on how such an effort might lead to later inclusion in a national publication followed.

Burris returned to the purpose of the publication. Will it be geared to strengthen W-1's position? Is there danger of the regional aspect being lost in the over-all if a three-region approach is taken? He emphasized that W-1 is a regional project.

Stratton clarified his motion as a review, summary, and interpretation of W-1 technical accomplishments, and restated the motion.

Motion carried.

Stonaker moved that Warwick be requested to carry from this committee the expression that the group would be willing to have this contribution incorporated into a final national contribution with the other regions. Flower seconded the motion.

Discussion of methods of financing followed. Ellis thought money could be found for such a publication in the Federal funds. Wheeler gave examples of how regional publications have been financed.

Motion carried.

Stonaker moved that Pahnish be requested to contact his publications department to inquire as to the relative cost of making reprints of the Literature Review from the present stencils, that the information be relayed to our Extension group, and, if there are enough orders to justify it, Dr. Clark be requested to send the stencils to Arizona to have reprints made. Gregory seconded the motion. Motion carried.

Bennett asked what has been done in keeping current on the Literature Review, and what are members to do with the material after they have reviewed their sections. Clark stated that all members who had accepted assignments were circularized and requested to inform him how far along they were with the assignment. Just a few contributors had offered information to date. Roubicek had informed Clark that in his opinion the next printing should be a revision including all additions to date--the original effort was not complete--and after the one revision supplements could be prepared from time to time. Clark referred to the limitations that determined the small number of copies in the first release. Discussion took place on the advisability of doing the work at one location.

Kidwell called for nomination of a representative to report to the committee on Record of Performance. Stratton nominated Bogart. Gregory seconded the nomination. There were no other nominations, and Bogart was elected.

The meeting recessed for lunch at 12 o'clock.

At 1:30 P.M. the meeting was called to order.

Wheeler reviewed the financial arrangements for W-1 out of regional research funds and stated that \$82,000 was approved for the project by the Western Directors in a recent meeting at Logan, Utah, with the respective allotments to the states as has been in effect.

A few projects were activated subject to new funds. A few older projects were given some, but very little, additional support. Wheeler relayed a request from the project review committee of the Western Directors regarding Objective 6 as listed in the new regional

project--to introduce and test new or derived breeds of beef cattle of known genetic merit to new environments. The review committee had stated that no procedures were developed under that objective and they did not see what is the contributing project included in Objective 6. This should be looked into. If the committee was in error it should be advised. (Note--Montana U. S. Range Station is engaged in this work).

Gregory requested a memorandum from Wheeler to the states regarding this, and Wheeler agreed.

Ellis reviewed the latest reorganization of the U. S. Department of Agriculture and said it resembled the organization in some respects that existed in the Department some thirty to forty years ago. He referred to two new basic research laboratories that are being planned to cut across Branches and Divisions. These are in the blood antigen and animal genetics fields.

Burris outlined the expansion that had taken place in State Experiment Stations Division. He cited the need for bringing state contributing projects up to date. He said he had been asked by State Experiment Stations Division to say something very complimentary about the Literature Review on Cattle Production. Everyone Burris had talked to thought it a very wonderful thing.

Dr. John Lasley of the University of Missouri then addressed the committee on the insulin technique.

"We have tested somewhere between 500 and 1,000 animals since last fall. We know very definitely that we are counting something other than standard white cells in making our count. Everyone wants to know what they are. We would like to know ourselves.

"Some animals do not give a clean-cut response one way or the other, constituting an overlap group.

"What do we know about the test, now? We know quite a bit, but there is still a lot we don't know. The demand to test animals and to show other people how to test them has been so great we have not had time to go on with the research we would like to do. You get pressure applied to go out and test a bull somewhere. You say the technique is in the experimental stage. You test the bull. The next thing is that the animal is advertised proved clean by our test.

"We do not know too much about the influence of age, season, breed, and area response on the test. Angus do not respond in quite as clear-cut a manner as do Herefords. Bulls do not respond quite as well as cows.

"We have been asked, what is our accuracy. We have missed very few known carriers of the gene. But we do call more pedigree-clean animals carriers than should be carriers.

"I am almost certain there are other things than just carrier characteristics giving us a response. What will an animal do under stress? An animal should be handled very carefully when being tested, especially in the blood drawing before the injections."

TABLE 1.--Number of cattle giving a clear-cut response as a carrier or normal after insulin injections during the winter and spring months.

Season when tested	No. of cattle tested	No. of cattle in which test was not clear-cut*	Percentage of cattle in which the test was not clear-cut
Winter (56-57)	76	17	22.37
Spring (57)	130	15	11.54
Totals	206	32	15.53

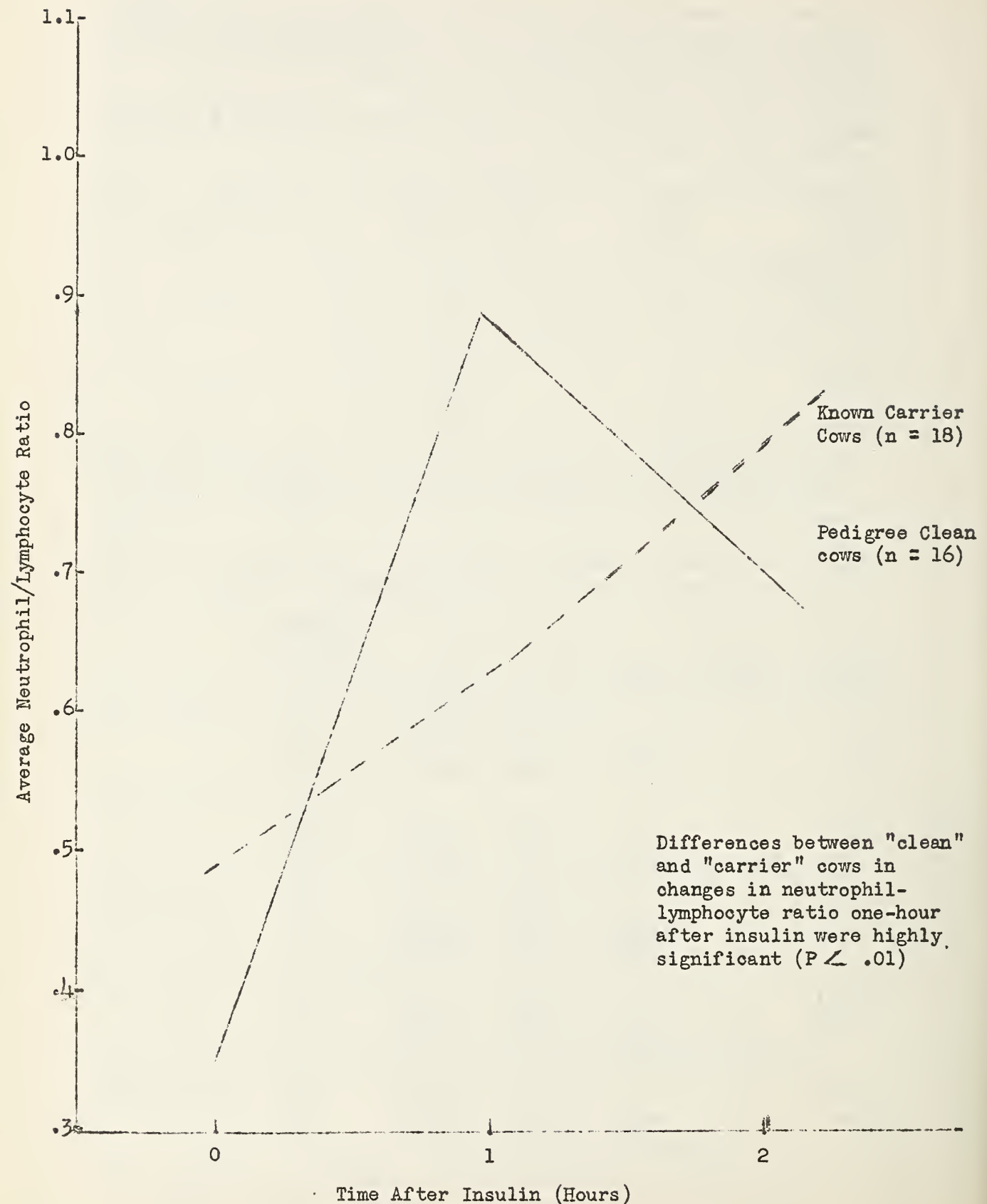
* Data were based on total cell counts alone. Attention to differential white cell counts is often helpful in making the test more clear-cut.

TABLE 2.--Response of cattle to insulin injections after being hauled 80 miles and tested immediately after arrival in Columbia.

Kind of animal	No. of blood sample	No. of cells per mm ³			Neutrophil lymphocyte ratio	Genotype
		Small*	Large	Total		
Bull No. 1	1	-	11,000	11,000	2.00	Known carrier
	2	8,300	6,750	15,050	1.74	
	3	15,300	7,500	22,800	1.75	
Cow No. 1	1	-	10,500	10,500	1.07	Ped. clean
	2	10,900	6,250	17,150	2.13	
	3	None	12,750	12,750	2.06	
Bull No. 2	1	-	6,750	6,750	.49	Ped. clean
	2	12,550	6,750	19,300	.87	
	3	7,050	5,500	12,550	1.31	
Bull** calf..	1	-	8,000	8,000	no slide	Ped. clean
	2	8,950	9,250	18,200	.71	
	3	3,900	10,450	14,350	.85	
Bull No. 3	1	-	11,750	11,750	.72	Ped. clean
	2	9,150	11,250	20,400	1.72	
	3	5,500	12,850	18,350	.56	

* Small cells were not counted in first sample.

** This calf was the offspring of cow number 1 and bull number 2.



Data Supplied by Dr. Dinkel, South Dakota Station

Dr. Clark then spoke.

"I will speak only briefly at this time. Every evening I read in our newspaper the statement of Bonfils, who established the Denver Post, 'There is no hope for the satisfied man.' In all of this work we are continually reminded of it. It will always be that way if we are decent research workers.

"I should say something about where I have been since I last saw you as a committee. As you know, I accepted a Fulbright Grant to Australia. On leaving Denver in February and after being in Hawaii a few days I arrived in New Zealand and met an animal husbandman in the person of Dr. C. P. McMeekan whom I had not seen since the late 20's or early 30's. I think he ranks among the top animal husbandmen in the world. I believe you are familiar with his work and would agree with that. Visiting the Ruakura station was a rich experience.

"You have been talking about Record of Performance. It is interesting to see what has happened in New Zealand where for the past quarter century this has been looked upon as a reasonable thing to do. McMeekan puts it this way: 'First, Usefulness--the objective. Second, Record of Performance or Progeny Testing--the method. Third, Realism--the additive.' He is a thought-provoking individual, and I had many questions to try to answer in regard to our work.

"It pays to get some little distance away and look back at what we are doing and realize some of it could well be modified. I can assure you Dr. M. C. Franklin of Commonwealth Scientific and Industrial Research Organization got me far enough back in the bush of Australia. Franklin is an inspiring individual with a tremendous amount of drive and rare intuition.

"One point in regard to our W-1 effort. We have a far tidier shop than we had ten years ago. Several big blocks of data collected by several stations have been processed at Denver by our joint effort between the Department and the states. Shelby has been unusually effective in getting this work done. There is living proof that we can work with the Armed Services people. We can work with any progressive group. We have access to the machines we need and can do the work at low cost.

"Mention has been made of the Literature Review. I wish Carl (Roubicek) could have heard Burris' statement. We will preserve as long as I am in Denver a eulogistic letter that came from Lanoy Hazel with regard to this Literature Review. It is a continuing job--it is not a finished production and never will be.

"You have heard me speak of animal introduction. In fact, I have talked on this subject many times without much visible effect so far. You are going to hear more about this in the next ten years than you have in the past. We know now this country will not always be confined to the British breeds. Some countries not far from us also are not satisfied with the present position--almost sole reliance on British breeds. They are doing something about it.

Veterinarians are recognizing that they will have to and can develop satisfactory quarantine measures and permit us to handle genetic material no matter where it comes from.

"In our organization in the Western Region we have had a wonderful opportunity to work with people, to gain information from a variety of sources, to work with industry, and to develop a better, more orderly shop. As I stated earlier, we have a far tidier research unit than we have ever had before, and it will continue to increase in effectiveness. Regardless of differences that some may have as to procedures, techniques, and thinking, we have stimulated sound research far beyond my fondest dreams when I started out at Bozeman to organize our three regional beef cattle projects, W-1, NC-1, and S-10.

"We have reached the place where we have a large and very important industry vitally interested in what we are doing. In regard to this idea of a summary publication, I am not going to rewrite your material except in a form which will be based upon the presentations which you as individuals submit to me. No single facet will be omitted from a review.

"Looking back to the amount of money McPhee planned for this type of work many years ago, the amount we now have is very small. Despite that, industry is working with us, and they are expecting big things. What we have done up to now represents a sizable achievement with what we have had to work with, but the real achievement is going to come within the next ten years. While getting under way we were plagued with a lot of inbred lines. Only a few of them are really promising.

"To come back to the Literature Review, if we really actively continue this review you will each actually have to carry out the assignments you accepted. Or, the other method proposed by Roubicek is to have a single person at the Denver office serve as the continuing reviewer with no other responsibilities. It is a full time job."

Kidwell called for action on the California revision and Gregory moved that this revision which had previously been circulated to the committee be approved. Bogart seconded the motion. Motion carried.

Bogart moved that a committee be appointed to prepare a manuscript covering the objectives and results of the Western Regional Beef Breeding Research and how our results can be applied on the ranch. This publication would define terms used and set up procedures which would be usable in western beef cattle improvement. It would be reviewed by the Western Regional Coordinator and the Federal Extension Service before publication. Each technical committeeman would cooperate with this committee in providing information. Stratton seconded the motion.

Stonaker in discussing the motion suggested tabling the motion until after the proposed meeting with Extension personnel since there would be a meeting of minds regarding recommendations.

Bogart hoped a manuscript could be prepared prior to the meeting and used in the sessions, and requested help from the committee. Kidwell said Bogart could enlist any members. Woodward asked if specific recommendations would be made, and reminded Bogart that many stations had already made their own recommendations.

Bogart emphasized that he had in mind showing how adjustments and comparisons could be made to fit specific conditions. Clark commented that quite a few states had prepared beef cattle improvement publications bearing on Record of Performance and that the farm press had been very helpful in getting the story across to industry. With this in view, perhaps an Extension type publication can now be presented in appropriate language and carrying a new and original approach.

Bogart recommended that suggestions from Extension men and project leaders be turned in to Dr. Clark and these would be turned over to Bogart, who would be glad to serve as leader of the committee.

Kidwell called for a vote. Motion carried.

Bogart moved a vote of thanks to the host institution for the very fine arrangements that had been made for the meeting.

Blackwell was confirmed as chairman of the W-1 Technical Committee for the coming year.

The business meeting was adjourned.

Dr. Shelby presented a request paper, "Methods of Estimating Heritability."

After Shelby's presentation, the meeting moved to the Meats Laboratory where C. O. Schoonover of the University of Wyoming gave a request demonstration of making carcass measurements in beef cattle, including his color photography technique in evaluation of rib eye cuts.

Dr. Lasley explained what to look for and what to expect during his demonstration of the insulin technique the following morning.

Meeting adjourned.

In the evening a dinner meeting was held in the Student Union. A number of University of Idaho staff members and their wives were present including President and Mrs. D. R. Theophilus.

Director Julius Nordby, who recently retired from the Western Sheep Breeding Laboratory, Dubois, Idaho, presented a very interesting illustrated lecture covering his and Mrs. Nordby's experiences under an I.C.A. mission to Egypt.

Methods of Estimating Heritability^{1/}
By C. E. Shelby

I have been asked to discuss some of the methods currently used to estimate heritability and to illustrate them with numerical examples. Since complete details of many of the techniques used have not been adequately described in the literature, and are found mainly in graduate theses, each step in the process will be explained in considerable detail.

Before the numerical examples are presented, the differences between the basic methods used to estimate heritability should be briefly reviewed. Since this subject has been covered very extensively by Dr. Lush in the paper, "Heritability of Quantitative Characters in Farm Animals", I will not attempt to present any new material, but instead will review those sections of his article pertinent to our present discussion. In the event that any of you are not familiar with this article, I would suggest that you obtain a copy. Dr. Lush has presented a very readable discussion of the various aspects of heritability. He has used actual examples to illustrate many of the theoretical considerations which can only be mentioned in the ensuing discussion.

The fraction of the total phenotypic variance which results from differences in the heredity of the individual members of a population is termed heritability. Its magnitude is important in evaluating the genetic merit of an individual animal, in choosing both the method of selection and the breeding plan, and in predicting the expected rate of progress in a selection program.

Lush (1949) defines heritability in both a broad and narrow sense. In the broad sense, it includes the effect of the entire genotype as a unit on the phenotypic variance, while in the narrow sense it includes only the fraction of this effect which is due to the additive or average effect of the genes.

The effects of heredity (h) may be divided into additive and nonadditive portions, as follows:

$$h = g + d + i$$

Where g is the additive or average effect of the genes on the observed phenotype,

d is the effect of nonlinear interactions of allelic genes (dominance), and

i is the effect of nonlinear interactions of nonallelic genes (epistasis)

Since improvement in the average genetic merit of a population results largely from the additive effect of the genes, an estimate of heritability in the narrow sense is an important tool in the hands of the

^{1/} Much of the material in this discussion was taken from Lush (1949).

animal breeder. Unfortunately, only in well designed experiments is it possible to completely separate the three basic components of the hereditary variance. Relatively few of our early breeding programs were designed with this purpose in mind. As a consequence, it is difficult to estimate their importance in the data now available. Nevertheless, methods have been devised which can be used to obtain estimates only slightly greater than one in the narrow sense.

In addition, most production traits in beef cattle are importantly affected by known genetic and environmental factors. Some of these are: age of cow, sex, inbreeding, age at weaning, age and weight on test, line of breeding, herd and year. Many important factors probably go unrecognized. In most instances, the magnitude of these influences can be estimated and suitable corrections can be made either in the statistical analysis or in the actual data before heritability is computed.

All methods used to estimate heritability are based on the fact that related individuals resemble each other more closely than unrelated individuals. Resemblances between relatives more remote than half sibs are of little value because of the extremely large number of animals required to obtain a reasonable degree of accuracy in an estimate.

As the environment of closely related animals is more apt to be similar than that of nonrelated animals, part of the decrease in variance between relatives is due to this factor. In most instances, the environmental component can be eliminated by proper experimental design. Otherwise, its magnitude must be estimated from data collected in breeders' herds and its effect removed before heritability can be estimated.

In full sibs or partially inbred lines, the variance due to dominance may affect the resemblance between animals.

A fraction of the epistatic variance is included in the resemblance between all types of relatives. For traits affected by a large number of genes, it is usually very small.

Environmental differences due to genetic peculiarities of parents or other ancestors are likely to be important in resemblances between dam and offspring or between maternal half sibs.

Nonrandomness of the mating system is seldom important in breeders' herds, but may be an important factor in inbred lines or herds closed to outside blood for several generations. In these instances, suitable corrections must be made in the analyses.

Selection based primarily on the individual's own phenotype may bias correlations, but will not affect regressions.

The following methods of estimating heritability are apt to be most valuable to the present group:

- (1) Regression of offspring on midparent
- (2) Selection experiments
- (3) Regression of offspring on parent
- (4) Correlation between full sibs
- (5) Correlation between half sibs

Regression of Offspring on Midparent

Regression of the offspring's record on the mean of the parent's record gives an estimate only slightly larger than heritability in the narrow sense. The additive genetic (or genic) variance, any genetic variance caused by the parental environment, and something less than half of the epistatic variance, are included. Nothing from the environment is included if the environments of parents and offspring were uncorrelated. No correction need be made for the mating system. Multiplication by a factor to compensate for incomplete genetic resemblance is not required. Sampling errors are not multiplied. Since they are relatively small, fewer observations are required for a dependable estimate of heritability. This method is not suited to characters expressed only in one sex or measured only by destroying the individual.

In my opinion, this method has been largely overlooked by the animal breeder. In all probability, records of both parents are available for the past ten years for traits such as birth weight, weaning weight, weaning score, and yearling weight, at most of the stations in this region. In addition, extremely large blocks of data are available at the older stations.

Selection Experiments

Selection experiments in which a high and low line are derived from an initial population by mass selection in opposite directions can be used to estimate heritability. In this method, the ultimate difference between the means of the two lines is divided by the total amount by which the phenotype of the parents of all generations exceeded the mean of the generation in which they were born.

Results of this method differ from the previous one in that epistatic variance is important only in the first and second generations of selection. If data from these two generations are discarded, an excellent estimate of heritability in the narrow sense will be obtained.

Regression of Offspring on Parent

The genic variance plus less than half of the epistatic variance is included in this estimate. If the environment of the offspring was partially determined by the individual character of either or both of the parents, or if there was a correlation between the environment of the parents and the offspring, an environmental component will be present.

In planned experiments environmental correlations may be reduced to zero by proper experimental designs. Similarity of environment is likely to contribute something to this resemblance if the data come from nonexperimental sources such as breeders' herds, from several different locations, or over a period of time long enough for time trends to have become important.

In most nonexperimental populations, deviations from random mating will be of little importance.

The regression of genic differences between parents on the phenotypic differences between them is measured by this method. In principle, the records of the offspring are used to indicate the genic values of their parents. If the regression is on an intra-sire basis, any differences resulting from females being mated to different sires are bypassed.

Correlation Between Full Sibs

This estimate will include the genic variance, half of the dominance variance, less than half of the epistatic variance, and twice any error made in subtracting out the environmental component. Full-sib and the parent-offspring resemblances differ in that full sibs have in addition one-fourth of the dominance variance, and are almost certain to have had more similar environments.

Correlation Between Half Sibs

The genic variance and a small portion of the epistatic are included in this estimate. If it is based on maternal half sibs, four times the maternal effect will be present. If the environmental differences between half sibs are as great as between nonsibs, an environmental component will not be included. If data were collected from several herds with each sire's offspring wholly in one herd, differences in average environment between herds can be removed by means of an intra-herd analysis.

Multiplication by 4 automatically multiplies any sampling error, or any error in removing the environmental component. This is a distinct disadvantage compared with the full-sib or parent-offspring method where multiplication is by 2, or with the regression of offspring on midparent where no multiplication is involved. Often, the amount of data available for half sibs is so numerous that the sampling error will be reduced sufficiently to offset this disadvantage.

Parental phenotypes are not necessary. Sibs can be used to measure resemblances in which the animal must be destroyed to measure them. Lastly, any effect of selection among the parents is very slight. Accuracy of this method depends much more on the number of degrees of freedom between sires than on the number of degrees of freedom within sires.

Literature Cited

Lush, J. L. 1949. Heritability of quantitative characters in farm animals. Eighth Internat. Cong. Genetics Proc. (Hereditas, Suppl. Vol.) pp. 356.375.

Numerical Examples of the Use of Half-Sib Correlation to Estimate Heritability Using Two Mathematical Models

The final feed-lot weights of 133 bulls fed in record of performance tests at the U. S. Range Livestock Experiment Station, Miles City, Montana, were used in these calculations. Bulls to be tested were selected at about five months of age largely on the basis of weight and conformation. Approximately 40 percent of the bull calves were castrated at this time.

The actual weights of the animals included in these examples are given in table 1. Records of the individual bulls are arranged by brands within sires within years. The records for each year are given on separate pages. The total sum of squares is indicated at the bottom of the last page of this table.

Tables 2, 3, and 4 give the subclass totals and subclass sums of squares by years, sires within years, and sires.

The mathematical models used were:

$$(1) \quad y_{ijk} = \mu + y_i + s_{ij} + e_{ijk}$$

$$(2) \quad y_{ijk} = \mu + y_i + s_j + e_{ijk}$$

The use of the hierarchical type of classification is illustrated in example 1. The mathematical expectations of the mean squares were equated to the mean squares, and the system of simultaneous equation solved by ordinary computational procedures to obtain the variance components.

In example 2, the mean squares were computed by a conventional least squares analysis for nonorthogonal data, equated to their expectation, and solved to obtain the variance components.

The assumptions necessary to use these two types of analysis are given by Henderson's (1953) Methods 1 and 3, respectively.

Table 5 gives the analysis of variance, the expectation of the mean squares, and the components of variance for example 1. Heritability was estimated by paternal half sib correlation in the conventional manner.

Table 6 gives the theoretical composition of the coefficients of the components of variance in table 5. The actual computation of these values is shown in table 7.

The least squares equations for example 2 are given in table 8. Table 9 gives the values of coefficients and N_{ij}/N_i used to absorb sires in table 8. Table 9 gives the equations after absorption. This type of table is always symmetrical about the main diagonal. The coefficients and sums in each classification add to zero. The equations were solved by iteration. The restriction $\sum S_i = \sum Y_j = 0$ was applied in order to obtain a unique solution.

Table 11 gives the following two solutions of the least squares equations:

(1) μ , S_i , and Y_j

(2) μ , and Y_j

Solutions of S_i were obtained directly in solution 1. These values were substituted into the original equations to obtain the $(\mu + S_i)$'s. Since $\sum S_i = 0$, the $(\mu + S_i)$'s were summed and divided by the total number of sires to obtain μ . The latter was subtracted from the $(\mu + S_i)$'s to obtain the S_i 's.

Table 12 gives the conventional analysis of variance for least squares equations. The reduction in sum of squares due to fitting μ , S_i and Y_j was obtained by multiplying the solution for each unknown by the right-hand side of the corresponding least squares equation and summing over-all equations.

A new set of least squares equations was set up and solved for μ and Y_j . The reduction due to fitting them was computed. The sum of squares for sires was obtained by subtracting $R(\mu, Y_j)$ from $R(\mu, S_i, Y_j)$.

Variance components were obtained by equating the expectation of the mean squares to the actual mean squares and solving the resulting simultaneous equations. Heritability was computed in the conventional manner.

TABLE 1.--Final Feed-Lot Weights of Miles City ROP Bulls From 1949-53

1949					
Year	Brand	Sire	cc	Final Weight	SS
49	297	104	1	871	
49	298	104	1	860	
49	299	104	1	822	
49	300	104	1	897	
49	301	104	1	820	
		104	5	4,270	
49	302	136	1	833	
49	303	136	1	790	
49	304	136	1	893	
49	305	136	1	810	
49	306	136	1	836	
		136	5	4,162	
49	307	144	1	839	
49	308	144	1	705	
		144	2	1,544	
49	291	152	1	829	
49	292	152	1	926	
49	293	152	1	799	
49	294	152	1	761	
49	295	152	1	787	
49	296	152	1	789	
		152	6	4,891	
49	285	196	1	747	
49	286	196	1	824	
49	287	196	1	846	
49	288	196	1	831	
49	289	196	1	848	
49	290	196	1	821	
		196	6	4,917	
49			24	19,784	16,362,850

1950					
Year	Brand	Sire	cc	Final Weight	SS
50	343	104	1	867	
50	344	104	1	988	
50	345	104	1	1,032	
50	346	104	1	932	
50	347	104	1	948	
		104	5	4,767	
50	335	152	1	1,038	
50	336	152	1	860	
50	338	152	1	1,017	
50	339	152	1	996	
50	340	152	1	947	
50	341	152	1	918	
50	342	152	1	914	
		152	7	6,690	
50	329	196	1	904	
50	331	196	1	915	
50	332	196	1	1,013	
50	333	196	1	907	
50	334	196	1	989	
		196	5	4,728	
50	337	234	1	787	
50	348	234	1	874	
50	349	234	1	916	
		234	3	2,577	
50	350	284	1	676	
50	351	284	1	864	
50	352	284	1	758	
50	353	284	1	840	
		284	4	3,138	
50			24	21,900	20,165,780

1951					
Year	Brand	Sire	cc	Final Weight	SS
51	395	152	1	1,048	
51	396	152	1	811	
51	397	152	1	1,023	
51	398	152	1	1,022	
51	399	152	1	891	
51	400	152	1	1,077	
51	401	152	1	1,017	
51	402	152	1	960	
		152	8	7,849	
51	411	188	1	983	
51	412	188	1	940	
51	413	188	1	1,005	
		188	3	2,928	
51	387	196	1	1,083	
51	388	196	1	977	
51	389	196	1	917	
51	390	196	1	983	
51	391	196	1	962	
51	392	196	1	964	
51	393	196	1	1,030	
51	394	196	1	998	
		196	8	7,914	
51	403	215	1	918	
51	404	215	1	1,033	
51	405	215	1	1,089	
51	406	215	1	967	
51	407	215	1	913	
51	408	215	1	861	
51	409	215	1	903	
51	410	215	1	904	
		215	8	7,588	
51			27	26,279	25,701,229

1952					
Year	Brand	Sire	cc	Final Weight	SS
52	464	196	1	884	
52	465	196	1	875	
52	466	196	1	985	
52	467	196	1	990	
52	468	196	1	1,066	
52	469	196	1	987	
52	470	196	1	878	
		196	7	6,665	
52	479	215	1	938	
52	484	215	1	904	
		215	2	1,842	
52	471	241	1	982	
52	472	241	1	827	
52	473	241	1	985	
52	474	241	1	985	
52	475	241	1	1,038	
52	476	241	1	923	
52	477	241	1	1,002	
52	478	241	1	951	
		241	8	7,693	
52	485	283	1	900	
52	486	283	1	1,054	
52	487	283	1	1,114	
52	489	283	1	927	
		283	4	3,995	
52	480	297	1	891	
52	481	297	1	926	
52	482	297	1	980	
52	483	297	1	864	
		297	4	3,661	
52			25	23,856	22,881,850

1953

Year	Brand	Sire	cc	Final Weight	SS
53	542	196	1	926	
53	543	196	1	974	
53	544	196	1	897	
53	545	196	1	932	
53	546	196	1	967	
		196	5	4,696	
53	561	292	1	1,107	
53	562	292	1	994	
53	563	292	1	999	
53	564	292	1	974	
53	565	292	1	1,016	
53	566	292	1	1,007	
53	567	292	1	1,055	
53	568	292	1	982	
53	569	292	1	924	
		292	9	9,058	
53	557	298	1	1,040	
53	558	298	1	1,040	
53	559	298	1	935	
53	560	298	1	1,044	
		298	4	4,059	
53	547	339	1	983	
53	548	339	1	970	
53	549	339	1	916	
53	550	339	1	1,089	
53	551	339	1	953	
53	552	339	1	820	
53	553	339	1	1,003	
53	554	339	1	959	
53	555	339	1	948	
53	556	339	1	788	
		339	10	9,429	
53	570	393	1	1,028	
53	571	393	1	1,010	
53	572	393	1	916	
53	573	393	1	906	
53	574	393	1	1,031	
53	575	393	1	825	
		393	6	5,716	
53			34	32,958	32,117,892

Total SS = 117,229,601 df = t-1
 CT = 116,188,803 = 134-1
 ss = 1,040,798 = 133

TABLE 2.--Subclass Totals and Sum of Squares by Years

Year	Brand	Sire	cc	Final Weight
49			24	19,784
50			24	21,900
51			27	26,279
52			25	23,856
53			34	32,958
			134	124,777
Year SS = 116,581,896 df = y-1				
CT = 116,188,803 = 5-1				
ss = 393,093 = 4				

TABLE 3.--Subclass Totals and Sum of Squares by Sires Within Years

Year	Brand	Sire	cc	Final Weight
49		104	5	4,270
49		136	5	4,162
49		144	2	1,544
49		152	6	4,891
		196	6	4,917
			24	19,784
50		104	5	4,767
50		152	7	6,690
50		196	5	4,728
50		234	3	2,577
		284	4	3,138
			24	21,900
51		152	8	7,849
51		188	3	2,928
51		196	8	7,914
51		215	8	7,588
			27	26,279
52		196	7	6,665
52		215	2	1,842
52		241	8	7,693
52		283	4	3,995
52		297	4	3,661
			25	23,856
53		196	5	4,696
53		292	9	9,058
53		298	4	4,059
53		339	10	9,429
53		393	6	5,716
			34	32,958
			134	124,777

Sires Within Years SS = 116,751,765 df = s-y
CT = 116,581,896 = 24-5
ss = 169,869 = 19

TABLE 4.--Subclass Totals and Sum of Squares by Sires

Year	Brand	Sire	cc	Final Weight
		104	10	9,037
		136	5	4,162
		144	2	1,544
		152	21	19,430
		188	3	2,928
		196	31	28,920
		215	10	9,430
		234	3	2,577
		241	8	7,693
		283	4	3,995
		284	4	3,138
		292	9	9,058
		297	4	3,661
		298	4	4,059
		339	10	9,429
		393	6	5,716
			134	124,777

Sire SS = 116,515,517 df = s-1
 CT = 116,188,803 = 16-1
 ss = 326,714 = 15

TABLE 5.--Analysis of Variance for Example 1

SV	DF	SS	MS	EMS
Total	133	1,040,798	7,825.55	$\sigma_e^2 + 0.959376 \sigma_s^2 + 0.802042 \sigma_y^2$
Between years	4	393,093	98,273.25	$\sigma_e^2 + 6.251590 \sigma_s^2 + 26.667910 \sigma_y^2$
Between sires within years	19	169,869	8,940.47	$\sigma_e^2 + 5.399508 \sigma_s^2$
Within sires	110	477,836	4,343.96	σ_e^2

Component	Actual	Percent
σ_e^2	= 4,343.96	51.0
σ_s^2	= 851.28	10.0
σ_y^2	= 3,322.62	39.0
σ_t^2	= 8,517.86	100.0

$$h = \frac{4 \sigma_s^2}{\sigma_s^2 + \sigma_e^2}$$

$$\frac{4(851.28)}{851.28 + 4,343.96} = \frac{3,405.12}{5,195.24} = 0.66$$

TABLE 6.--Theoretical Composition of the Coefficients of the Components of Variance in Table 5

SV	σ_e^2	σ_s^2	σ_y^2
Total	1	$\frac{N.. - \frac{\sum \sum N_{ij}^2}{N..}}{t-1}$	$\frac{N.. - \frac{\sum \frac{N_{i.}^2}{N..}}{t-1}}$
Between years	1	$\frac{\sum_i \left(\frac{\sum_j N_{ij}^2}{N_{i.}} \right) - \frac{\sum \sum N_{ij}^2}{N..}}{y-1}$	$\frac{N.. - \frac{\sum \frac{N_{i.}^2}{N..}}{y-1}}$
Between sires within years	1	$\frac{N.. - \sum_i \left(\frac{\sum_j N_{ij}^2}{N_{i.}} \right)}{s-y}$	
Within sires	1		

Where N_{ij} is the total number of bulls sired by the j th sire in the i th year,

$N_{i.}$ is the total number of bulls born in the i th year, and

$N..$ is the total number of bulls fed.

TABLE 7.--Actual Computation of the Coefficients of the Components of Variance in Table 6

SV	σ_e^2	σ_s^2	σ_y^2
Total	1	$\frac{134 - \frac{858}{134}}{134-1}$ = 0.959376	$\frac{134 - \frac{3,662}{134}}{134-1}$ = 0.802042
Between years	1	$\frac{31.409345 - \frac{858}{134}}{5-1}$ = 6.251590	$\frac{134 - \frac{3,662}{134}}{5-1}$ = 26.667910
Between sires within years	1	$\frac{134 - 31.409345}{24-5}$ = 5.399508	
Within sires	1		

TABLE 8.--Least Squares Equations for Example 2

Sires														Years										Final	
														49	50	51	52	53	Weight						
														24	24	27	25	34							
														5	5	5	8	3							
														6	6	8	7	5							
														10	10	8	2	5							
														3	3	3	8	3							
														10	10	8	2	5							
														3	3	3	8	3							
														10	10	8	2	5							
														3	3	3	8	3							
														10	10	8	2	5							
														3	3	3	8	3							
														10	10	8	2	5							
														3	3	3	8	3							
														10	10	8	2	5							
														3	3	3	8	3							
														10	10	8	2	5							
														3	3	3	8	3							
														10	10	8	2	5							
														3	3	3	8	3							
														10	10	8	2	5							
														3	3	3	8	3							
														10	10	8	2	5							
														3	3	3	8	3							
														10	10	8	2	5							
														3	3	3	8	3							
														10	10	8	2	5							
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														10	10	8	2	5							
														3	3	3	8	3							
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														3	3	3	8	3							
														10	10	8	2	5							
														3	3										

TABLE 9.--Values of Coefficients and N_{ij}/N_1 . Used to Absorb Sires by Years

	49	50	51	52	53	Final Weight
104	5(.50000000)	5(.50000000)				9,037
136	5(1.00000000)					4,162
144	2(1.00000000)					1,544
152	6(.28571429)	7(.33333333)	8(.38095238)			19,430
188			3(1.00000000)			2,928
196	6(.19354839)	5(.16129032)	8(.25806452)	7(.22580645)	5(.16129032)	28,920
215			8(.80000000)	2(.20000000)		9,430
234		3(1.00000000)				2,577
241				8(1.00000000)		7,693
283				4(1.00000000)		3,995
284		4(1.00000000)				3,138
292					9(1.00000000)	9,058
297				4(1.00000000)		3,661
298					4(1.00000000)	4,059
339					10(1.00000000)	9,429
393					6(1.00000000)	5,716

Sires

TABLE 10.--Equations After Absorbing Sires by Years

	49	50	51	52	53	Final Weight
49	+11.6214239	- 5.4677119	- 3.8341014	-1.3548387	-0.9677419	-1,589.34809350
50	- 5.4677119	+11.3602150	- 3.9569892	-1.1290322	-0.8064516	+ 525.31734370
51	- 3.8341014	- 3.9569892	+12.4878648	-3.4064516	-1.2903226	+ 941.86933820
52	- 1.3548387	- 1.1290322	- 3.4064516	+7.0193548	-1.1290322	+ 90.67746600
53	- 0.9677419	- 0.8064516	- 1.2903226	-1.1290322	+4.1935484	+ 31.48394560

Years

TABLE 11.--Solutions of the Least Squares Equations

	Solution 1 μ, S_i, Y_j	Solution 2 μ, Y_j	N	Final Weight
104	+ 27.7554		10	9,037
136	+ 18.4477		5	4,162
144	- 41.9523		2	1,544
152	+ 8.1339		21	19,430
188	- 0.2396		3	2,928
196	+ 8.8717		31	28,920
215	- 26.8494		10	9,430
234	- 78.9369		3	8,577
241	+ 17.3365		8	7,693
283	+ 54.4615		4	3,995
284	-153.4369		4	3,138
292	+ 76.1157		9	9,058
297	- 29.0385		4	3,661
298	+ 84.4213		4	4,059
339	+ 12.5713		10	9,429
393	+ 22.3380		6	5,716
49	-106.5969	-102.4111	24	19,784
50	+ 17.3877	- 14.2444	24	21,900
51	+ 55.6904	+ 46.5519	27	26,279
52	+ 23.7393	+ 27.4956	25	23,856
53	+ 9.7795	+ 42.6085	34	32,958
μ	+920.5492	+926.7444	134	124,777

$$\begin{aligned}
 k(\mu, S_i, Y_j) &= 116,748,990 \\
 CT &= 116,188,803 \\
 SS &= 560,187 \\
 df &= s+y-2 \\
 &= 16+5-2 \\
 &= 19
 \end{aligned}$$

$$\begin{aligned}
 R(\mu, Y_j) &= 116,594,799 \\
 CT &= 116,188,803 \\
 SS &= 405,996 \\
 df &= y-1 \\
 &= 5-1 \\
 &= 4
 \end{aligned}$$

TABLE 12.--Analysis of Variance for Example 2

SV	DF	SS	MS	EMS
Total	133	1,040,798		
$R(\mu, S_i, Y_j)$	19	560,187		
$R(\mu, Y_j)$	4	405,996		
Between sires	15	154,191	10,279.40	$\sigma_e^2 + 7.94 \sigma_s^2$
Error	114	480,611	4,215.89	σ_e^2

$$\sigma_e^2 = 4,215.89$$

$$\sigma_s^2 = 763.67$$

$$\sigma_e^2 + \sigma_s^2 = 4,979.56$$

$$\begin{aligned}
 h &= \frac{4\sigma_s^2}{\sigma_e^2 + \sigma_s^2} \\
 &= \frac{3,054.68}{4,979.56} \\
 &= 0.61
 \end{aligned}$$

$$\begin{aligned}
 k_o &= \frac{1}{n-1} \frac{(\sum N_i - \frac{\sum N_i^2}{\sum N_i})}{\sum N_i} \\
 &= \frac{1}{16-1} \frac{(134 - \frac{1994}{134})}{134} \\
 &= 7.94
 \end{aligned}$$

